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THE NEW FOREST

BY DAVID W. YOUNG

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INTRODUCTORY.

THE New Forest has a chequered history behind it. Naturally, like every other forest it is a living record of its history. It bears in its corpus, trees, vegetation, and soil, the effects of those things which have happened to it for good or ill. Where a forest's history has been more or less consistent it can be disposed of in a word or two. About the history of the New Forest there has been little that was consistent. Its ragged and rather incoherent enclosures bear the marks, and its administration is hedged about by a number of statutes and gentlemen's agreements—the expression of many compromises—which make straightforward forestry very difficult. It is, moreover, the first in all but name of Britain's National Parks. Its woods and plantations are a definite part of its amenities and have to be managed with due regard to that fact. In some minds this detracts from its interest. That is a pity. Even that bugbear of many practical foresters, Forest Aesthetics, is a branch of the science or art of forestry which is of vital importance to state forestry in this country. Its proper development may well prove to be a necessary preliminary to advance on to some of the better areas. After all there is a close relationship between the general fitness of things, whether viewed from the aesthetic or silvicultural standpoint. Transcendental as this may sound, it is merely a recognition of that intuitive element in our mental make-up which carries us beyond the limits of conscious knowledge which in forestry are all too narrow. To take a very simple instance, there is a sense of satisfaction about a beechwood whose warm brown floor is spangled with patches of *Oxalis* that is entirely lacking when the *Oxalis* is replaced by *Molinia*—even though it be in early summer when the green of the grass is not very different from that of the *Oxalis*. A forester can explain this, but the layman who reacts in much the same way expresses his reaction in terms of aesthetics. In nine-tenths of the phenomena with which we deal, we foresters still remain laymen with a background of unformulated experience whose promptings are scarcely distinguishable from intuition. This is not entirely a digression. The New Forest abounds in examples of this kind of thing. How they have come about is a matter of history, and a mere description of the forest and its present administration without its historical background becomes irrelevant in consequence. It is proposed therefore to make this largely an historical study. Firstly, a brief description will be given of the forest as it exists to-day. The second section will be devoted to an attempt to piece together from the data available the stages through which it passed to reach its present condition. Finally, in more or less summary form, the present problems will be discussed and an outline given of the ways in which they are being tackled.

GENERAL DESCRIPTION.

1. *Locality and Area.*

The New Forest occupies an area of roughly 145 square miles between Southampton Water and the River Avon. Not all of this is Crown land. Rather less than a third consists of freeholds, privately owned, occupying island sites or sites along its boundaries. The actual figures are as follows:

			Acres
Private lands			27,658
Forestry Commission's lands:			
Woodland:			
Enclosed: freehold	1,111		
statutory	15,745	16,856	
Unenclosed: enclosurable	1,927		
non-enclosurable	5,000	6,927	23,783
Residential and agricultural			978
Open heath			39,946
		TOTAL	92,365

The differentiation of the various categories of Crown land will be dealt with later.

2. *Climate.*

Practically on the coast, the forest enjoys a coastal climate, though it is sufficiently inland to avoid the direct effect of air-borne salt to any marked extent. Its average rainfall is about 33 inches. In an average year two-thirds of this precipitation will occur between October and March, October with an average of 4·1 is the wettest month, and May with less than 2 inches the driest, but March and April with 2·4 inches run it close, an important factor in fire risks. The summer precipitations are spread over 90 days on the average.

The maximum, mean, and minimum average daily temperatures are 59° F.; 50° F., and 41° F. respectively. From April to September, April has the lowest average, 47°, and July and August the highest, 62. Winters are very mild, and only on one or two days in January and February may the temperatures be expected to drop to 20° F. In many years there is no snow—on the average it lies only five days in the year. Gales are seldom experienced. In all respects a very favourable climate for forestry.

3. *Physiography.*

The Forest occupies a gently rolling country mainly between altitudes of 100 and 200 feet. It reaches its highest elevation in the north (421 feet) and slopes down to almost sea-level in the south. The slopes are nowhere steep. Rounded hills and plateaux slope gently to shallow valleys which drain away by irregular courses to the Solent through the Lymington and Beaulieu rivers. The streams have a very low gradient, seldom more than 1 per cent., which often makes effective drainage—particularly maintenance of drains—difficult.

4. *Geology and Soils.*

The soil of the area is extremely variable and on the whole poor. Sands and gravels of the Bracklesham and Barton (Bagshot) beds predominate, but clays of these and newer (Oligocene) beds cover considerable areas. Plateau gravels are widely distributed over a great part of the area. As a rule the hills are capped with gravel, and the valleys have beds of clay of varying consistency. Thus the soils vary from pure sands, or sands and gravels associated with a layer of shallow peat, through sandy loams and loamy clays, to stiff clays in the valleys, frequently associated with peat of bog origin. The majority of the woods and the enclosures almost exclusively occupy soils derived from the Barton beds, though small portions extend to the Bracklesham beds and plateau gravels.

5. *Vegetation.*

For the purpose of describing the vegetation, it is necessary to differentiate between open heaths and woods. Fully half the woods occupy a central position, making a more or less continuous massif about 9 miles long and 3 wide, whose main axis runs roughly WNW. to ESE. Round this central massif are extensive open heaths, the remainder of the woods occupying island sites in their midst, or positions along the northern or southern boundaries.

Calluna vulgaris, *Erica cinerea*, and short *Molinia* make up the bulk of the vegetation occupying the hill-tops and plateaux of the open heaths. Bracken occurs densely on the lighter soils, and gorse becomes abundant in places, mainly in the vicinity of hamlets and villages. In the valleys the heaths give way to strong *Molinia*, and this in turn to bog associations. These may also occur, though in less luxuriance, on the plateaux in places where the gravel layer is shallow and rests on clay, or where pan conditions prevail. In all but the bracken areas the shallow peat of the heather areas with a lichenous growth on its surface forms in itself an impermeable layer, and keeps the surface in a more or less boggy condition throughout the winter.

Not unnaturally, the greater proportion of the woodland area of the forest occupies the stronger lands, loams and clays, than is the case with the open heaths. Consequently *Molinia* is far more and heath far less frequently the predominant species in the woods than in the open heaths. This is not only a question of soils, because except on the very lightest soils heather tends to disappear from the woodland vegetation quite early, while the *Molinia* is very persistent. A striking feature of the woodlands, particularly the enclosures, is the almost complete absence of typical woodland flora, and with one or two very small exceptions, of any other underwood than holly. This is in marked contrast with the private woods around on much the same types of soil, and which it should be noticed are within the bounds of the forest and have been subject to the same forest laws. As a general rule and subject to small modifications due to shade, the vegetation of the enclosures can be identified with that of the open heath outside. There are very few places where primroses and hyacinths, which are a feature of the private woods, appear in any abundance. Anemones are scarce and confined to the old woodland areas

and typical woodland grasses such as *Millium*, the wood melleck, and hairy brome, are met with only occasionally. Naturally the floors of the young conifer woods in closure and the dense beech stands are practically devoid of vegetation. Elsewhere, the vegetation is a slightly modified form of the vegetation on the same type of soil outside. On the sandy soils, bracken, heather, and bilberry become in the woods a light covering of bracken and

increased abundance of bilberry. Heather and *Molinia* types, with or without bracken, yield a vegetation in which heather gives way as the predominant species either to the *Molinia* or bracken. On the wettest soils, a sward of *Molinia* gives way to a more hummocky formation. A strong increase of blackberry and honeysuckle and mosses is really the only essential change in the vegetation towards a woodland character in the enclosures.

This description is not entirely applicable to the unenclosurable woods. As will be seen, they consist mainly of beechwoods more or less dense in canopy and generally too dense for much vegetation. Where the trees open out the forest litter gives way to a grassy sward close cropped by the Commoners' animals and dotted about with holly and thorn. Beyond the limits of the trees, however, the typical heath vegetation soon reasserts itself.

6. *Growing Stock.*

There is a wide difference between the unenclosurable woods and enclosures —in age, origin, stocking, and species. The former have not been enclosed since 1700, if at all, while all but a small part of the enclosures have been felled and regenerated during the last 150 years.

The Unenclosurable Woods. There are one or two interesting exceptions, but the majority of the unenclosurable woods are stocked mainly with beech. Though oaks do occur the proportion generally is under 15 per cent. In places it may reach as high as 50 per cent. and in patches even pure brakes occur, but these are very exceptional. These woods are of uneven age and obviously of natural origin. Trees of the oldest age classes make up the bulk of the stocking. They are generally old pollards with their main branches growing up from a point 8 to 10 feet from the ground fastigate fashion to build enormous crowns. Height growth is often very good, reaching over 90 feet, although in the majority of cases it is considerably less. In such places one occasionally sees a younger tree which has never been pollarded and has pushed its way into the main canopy. Its full-bodied stem gives some idea of what these old woods might have been but for the practice of pollarding to provide browse for deer. The exceptions referred to are almost pure oakwoods, and lines can be traced amongst the trees showing their artificial origin.

In the pure beechwoods there is little or no herbage but generally an undergrowth of holly, almost to the exclusion of everything else. If the holly undergrowth is at all strong a few sapling beech, and occasionally oak, may be seen growing up through it, and where the conditions are good there may be a quite fair proportion of middle-aged beech with an oak or two amongst them, but these are exceptions. These woods with strong holly growth occasionally get swept with fire, killing all the young saplings. In woods where the holly growth is not strong, both poles and saplings are lacking. After mast years, a few patches of regeneration may survive for a few years though closely browsed, but they soon disappear.

The older trees vary greatly in age and condition. Sporadic deaths are frequent in all the woods, but while in some the state of decay has not gone very far others are rapidly crumbling away. The famous Mark Ash wood is a case in point. Each winter's gales takes its toll. Even in the woods with strong protective holly, the regeneration is seldom sufficient to make up for the losses. The wastage in consequence is increasing; at present this is only apparent to those who study the woods. An exceptional gale which anticipated the natural casualties of two or three years in a single night would perhaps make it patent to all. As the law stands nothing can be done to remedy matters.

The Enclosures and Enclosurable Woods. It must be confessed, however, that the enclosures as they stand to-day do not offer an encouraging picture of what might be done. A not very large proportion of them are the outcome of direct afforestation of open heaths, but the majority are the result of clearing old woods of much the same type as has been described and replanting. It

would be wrong to speak too disparagingly of them. There are many fine stands among them. Taken as a whole, however, they are not very satisfactory, and as the outcome of a century and a half of forestry effort scarcely flattering to foresters. The spasmodic character of these efforts, and the opposition they aroused has to be taken into account. The administration of the forest has never been easy. When all such allowance has been made, however, there is a surprising lack of evidence that a deeper knowledge has been gained in all these years of the intrinsic problems which the forest's initially refractive soils present.

The stocking as it stood in 1929, the beginning of the present Working Plan period, is analysed in the table on p. 7. The abnormality of the age-class distribution which the table discloses strikes the eye at once. How this has come about will be clear from the historical notes which follow. The real character of the change which has been wrought, however, only comes out when it is mentioned that of the 9,213 acres of hardwood stands, all under 140 years of age consist of almost pure oak. What must have been predominantly beechwoods have given place to some 5,000 acres of conifers and 8,000 acres of oakwoods from which, disregarding the under-planting efforts of the last 20 years, the beech has been more or less completely eradicated. The change was a revolutionary one. How far it can be justified is questionable. It is, however, the outstanding differentiation between the old unenclosed woods and enclosures.

It would be impossible to give any general description of such a wide assortment of plantations here. It will be necessary to refer to some in detail later. All that can be done is to pick out a few outstanding features of them taken in the mass. The hardwoods below 150 years are practically all pure oak. These in the age-classes 100 to 150 years are not very different from the same age-classes in other Crown woods. The New Forest has a greater proportion of sessile oak than the Dean, for instance, but its woods tell the same tale of overthinning, and the timber in many places is very shaky, particularly on gravelly soils. Short-boled trees with coarse branchy crowns is the general picture on heavy land, but on the lighter soils the height growth is often quite good. Die-back is frequent, especially on the wetter soils. Its incidence makes one dissatisfied with the generally accepted explanation that defoliation and mildew are the main cause. No doubt they have helped, but all the indications are that some probably temporary defect of the soil is mainly responsible.

Perhaps it will save repetition to discuss this point here. Die-back in this forest is not confined to the oak. It occurs with pines, sweet chestnut, and other species as well. The typical history is very similar in all. An apparently healthy tree begins to droop its leaves or suffer chlorosis in its needles. The next year it is dead. The only difference is that the oak, more tenacious of life, may hang on for a year or two with its lower branches swathed in epicormics. Examination of the butts or roots of the dying trees discloses in the case of the oak honey fungus, and in that of the chestnut ink disease more or less well developed, and in the case of pines the roots are generally covered with black

pseudo-mycorrhiza. The incidence is generally associated with ground which has become wet through choking of drains, but die-back occurs in other situations—in places, for instance, where through some cause or another there is an accumulation of raw humus. It is less frequent in mixed woods than in pure.

New Forest—Age-Classes

Working Circle.	*Conifers.*	*Hardwoods.*	*Amenity.*	*Total.*
Age-Class.	*Acres.*	*Acres.*	*Acres.*	*Acres.*
		I. Conifers.		
1–20	2,171·34	464·11	48·49	2,683·94
21–40	372·36	10·55	..	382·91
41–60	1,635·99	558·82	..	2,194·81
61–80	345·20	1,433·12	..	1,778·32
81–100	11·98	11·45	..	23·43
101–120	90·63	44·51	..	135·14
121–140	1·00	6·40	..	7·40
	4,628·50	2,528·96	48·49	7,205·95
		II. Hardwoods.		
1–20	27·44	338·92	16·87	383·23
21–40	3·80	7·00	..	10·80
41–60	116·18	494·48	..	610·66
61–80	97·17	129·01	..	2,026·18
81–100	77·47	437·55	..	515·02
101–120	198·05	3,999·52	..	4,197·57
121–140	..	..	..	..
141–160	80·32	366·69	308·71	755·72
201–225	..	147·48	96·92	244·40
Uneven up to 400	28·37	43·77	397·67	469·81
	628·80	7,764·42	820·17	9,213·39
		III. Bare and Scrub.		
	742·82	154·91	154·74	1,052·47

TOTALS

Working Circle.	*Conifers.*	*Hardwoods.*	*Amenity.*	*Totals.*
Age-Class.	*Acres.*	*Acres.*	*Acres.*	*Acres.*
I. Conifers . . .	4,628·50	2,528·96	48·49	7,205·95
II. Hardwoods . .	628·80	7,764·42	820·17	9,213·39
III. Bare and Scrub .	742·82	154·91	154·74	1,052·47
	6,000·12	10,448·29	1,023·40	17,471·81

Though frequently associated with wet land the water-logged state of the land is not always the direct cause. There are large areas in the open forest of self-sown scrub pine where the land has always been boggy—yet the pine seem to hang on indefinitely.

The occurrence of the honey fungus in oak is particularly interesting. The

fungus is believed to be present in most oakwoods in this country. Is it possible that it normally functions as a mycorrhiza on the oak, and becomes parasitic under certain unfavourable soil conditions?

This rather dismal picture is not true by any means of all the oakwoods of the 100 to 150 or any other age-class in the forest. Some of the exceptions are instructive. There are in the Bentleys, for instance, stands of uneven-aged woods with some admixture of beech 200 years old and over, where the timber is first class though rather branchy. There are several enclosures carrying stands of various age-classes which have been closed for some time, and where for some reason or another the enclosure has been completely effective in avoiding trespass by ponies and cattle. Here the picture is very different. Beech and thorns have come in freely to form an underwood. Grass has given way almost entirely to mosses. Natural regeneration of conifers and hardwoods alike is abundant, and provided the drains have been kept open growth is generally very good.

The oak pole woods (40–100) which, as will be seen, cover a considerable area, are, except on the wettest ground, very promising. They have been kept dense and have killed out vegetation, but now as the canopy lightens grass, generally *Molinia*, is reasserting itself, and die-back begins.

In some respects, though not always the most promising, the 1–20 age-class of the hardwoods are the most interesting. They exemplify a variety of methods of oak regeneration. There is, for instance, in Salisbury Trench as pretty an example of natural regeneration of oak as will be found in the country.

Even the very sketchy description of the broad-leaved woods would be misleading if one other point was not mentioned. The best of the pure even-aged oakwoods, to whatever age-class they belong, give a sense of dissatisfaction hard to define—a feeling of sterility, which is not completely removed when an under-story of beech has been established by underplanting or natural regeneration. It disappears completely, however, where the woods abut on to a group or row of older trees of some other species. Just occasionally one comes across well-drained places where oak poles or seedlings are thrusting their way up amongst groups of older beech or even pines. The ground is clear of herbage and the oaks show a thrusting vigour. This grouping satisfies both aesthetically and silviculturally, and provides the conditions in which the oak appears to thrive best.

The great majority of the conifer woods over 20 years are Scots pine woods. They are mainly the introduction of the last 80 years. Though not indigenous, Scots pine is the species most at home in the forest. It thrives on all but the wettest soils whether sands or clays. It seeds itself all over the open heaths. With but little protection the whole forest would become a pure pine forest by natural regeneration within a century. The pines, however, are an offence to Commoners and a large section of the public. The Forestry Commission has undertaken to keep their extension in check. For the moment their existence, even in enclosures, is only tolerated. We are approaching a time however, when their crowns will flatten out and let shafts of light on to their

red stems. The ugly ducklings will then have become swans and the public attitude towards them is likely to be very different. This will ease matters in some respects, but may complicate them in others. Exploitation of such trees will be jealously watched.

The quality classes of the sites naturally change very much amongst such variable soils. Second- and third-quality sites according to the Commission's tables are most frequent, but a small proportion of first-quality sites are met with.

The oldest stands were planted as nurses for oaks. The nurses have overlaid their charges, though a few oaks remain amongst them. These areas often provide the finest trees and the soil conditions are excellent, but the trees tend to be coarse and branchy. Little attention has been paid in the past to insect pests. The pine beetle has done much damage in many of the best stands, ruining the trees for telegraph poles. There is less sign of pine tortrix epidemics, though it too is present. Nor has a great deal of attention been paid to thinning. This has not been entirely detrimental in every case. Some of the finest poles are to be found in woods neglected in this way. Where, however, trees have suffered from insect or storm damage failure to remove the damaged or deformed stems early has often been disastrous. Taken as a whole the pinewoods make up a very valuable part of the forest growing stock. Worked on a long rotation they will yield magnificent saw timber.

In the 1–20 age-classes of the conifers the two spruces, Douglas fir, larch, and Corsican pine are well represented. Their introduction is not an innovation. Amongst the older age-classes there are stands, groups, and individual trees fully justifying their selection. But in many respects these plantations are not very satisfactory. They have been established under many adverse conditions. The majority of them were planted on areas cleared during the War. In most cases there was a lapse of four or five years between clearing and planting. During that time a strong vegetation grew up and undue economy in weeding, for which the local staff were not generally to blame, has certainly aggravated matters. Fires, damage by cattle, and insects were further adverse factors. There are many exceptions on the other hand which serve by contrast to bring out the comparative failure of the rest. It is easy to be too pessimistic about these plantations. There is something refractory about forest soils so long as they carry their non-woodland vegetation, which disappears when it is suppressed. It is remarkable how frequently one comes across statements in old papers both here and in the Dean to the effect that larch does not do well in these forests—yet both contain plantations of larch of exceptional merit. It is quite probable that these were the very plantations about which in their early stages the writers were so pessimistic. To-day one sees plantations of larch, Douglas fir, and spruce looking very unthrifty, others changing for the better, and yet others in thriving condition which are known to have made a very poor start. One great saving factor in the New Forest is the way naturally regenerated pines help to fill up. Judging by some of the older stands these plantations are likely to be all the better for being mixed.

Undoubtedly the chief difficulty is the vegetation. Within a year or two, if

the plantation does not spring away from the start, it is contending with a dense growth of natural open forest herbage which means a more or less extended period of check. The persistence of this herbage is due to two chief factors. Firstly, overthinning, which has left the herbage with the light it needs, and secondly and more importantly, grazing by trespassing cattle which has prevented any underwood but holly ever getting up.

These things are changing, and a point to be emphasized is that the best of descriptions give a static picture of a forest, which is misleading. A forest is a dynamic thing, and in certain phases of its history the changes going on are more important than in others. This is particularly true of the New Forest just now. Many changes are manifest, varied, and rapid. Others not so easily apprehended are no less important. We are reaching the end phase of a rotation of pure oak and pine plantings. As already mentioned, it is suspected that these have set severe biological and possibly chemical strains on the soil. Only in a few places can rapid accumulation of raw humus be pointed to. However definite the misgivings there is little definite about the manifestations. They vary from place to place and are difficult to interpret.

Two very definite factors of change can be mentioned, however. One wholly beneficial and the other the reverse. Only during the past twelve years or so has the ill effect of grazing been really fully appreciated. Trespass during that time has been steadily suppressed. Its complete elimination is difficult in a national park, but the effect of the greater vigilance is obvious and accelerating. When the enclosures were first made there was an elaborate system of drains laid down. Over large areas in the New Forest an effective drainage system is the very condition of maintenance of plantations worthy of the name. So long as the drains were effective this was not appreciated. Now that they begin to be silted up it is obvious to every one. To get them right at once would be a colossal task. What can be done is being done, but it does not keep pace with the deterioration going on elsewhere. Ways and means of a more drastic tackling of the problem are under consideration.

THE HISTORY OF THE NEW FOREST.

Conditions of the forest in early times.

This emphasis on the importance of drains does not consort well with the popular conception of the forest in its primeval state as a vast forest of trees. How did they thrive without man's drains? The unenclosurable woods suggest an answer. Trees survive there on the hills and well-drained slopes, in the plateaux and valleys they give way to scrub and thorn. In King Canute's day the forest was known as 'Ytene', which has been translated as 'Furzy Place'. Gorse, which is what we mean nowadays by furze, though abundant is by no means the outstanding feature of the forest vegetation. The indications are that as the result of fires it is more abundant to-day than it ever was. Records of the sixteenth century give an account of how the encoppicements were enclosed. Furze was planted on the banks. About the same time we get presentments by regarders of the forest of copse fences being carried away for

coaling. One does not use gorse to make charcoal and one is forced to the conclusion that furze is used as a generic name for thorns and scrub. This gives us a picture of the forest as a place of thorns and scrub with timber-bearing woods on island sites in the well-drained places.

Two more important questions prompt themselves with regard to the prehistoric forest. Has the beech always held the same predominance it enjoys to-day in the unenclosurable woods, and has holly always been the predominant underwood? To the second point history provides us with an immediate answer. The object of the encoppicements already referred to was coppice in which hazel and ash figured largely. The object of the fences was to protect the young shoots and the natural regeneration of the standards from cattle and deer. Despite innumerable statutes and proclamations these fences were not maintained. Indeed, there are records of keepers using the copses as paddocks to prevent their cattle from straying. Hazel and ash which abound in private woods of the forest are almost completely wanting in the Crown enclosures in consequence. The first question is more difficult. It is at least significant that it should be asked about a forest that is famous for the oak which it has supplied to the Navy. Four times in its history censuses were taken of the amount of Navy timber (oak) in the forest, which give interesting cross-sections of the production of the forest during a period of 175 years.

These figures afford a side-light on what was happening to the forest during the seventeenth and eighteenth centuries, but their immediate interest rests in the numbers of trees found in the 1608 survey. Strictly the number given is an interpolation by the Commission who reported in 1789. Records of the 1608 survey gave them only the number of loads. The Commission based their calculation of numbers of trees on the average volume of trees found in 1783, namely 1·65 loads. The survey of 1764 showed an average of 1·85, which would probably have been a safer basis for calculation. Even if we set the number of trees as low as 100,000 this, taken with its natural complement of younger-aged classes, represents a quite heavy stocking. It would leave very little room for an admixture of beech if the area of woodlands was confined to the 6,000 acres of encoppicements known to exist then. If, as is more likely, the actual area of woodlands was very much as it is to-day, the proportion of beech would be between 50 per cent. and 70 per cent. That is probably as near as one can get, and it is only safe to assert that the oaks for which the forest was famous grew up with a very considerable admixture of beech.

Date of survey.	*Description.*	*No. of trees.*	*No. of loads.*	*Total loads.*
1608	Timber fit for Navy . . .	123,927	197,405	
	Dotards and Decayed trees . .	Wanting	118,072	315,477
1707	Timber fit for Navy . . .	12,476	19,873	19,873
1764	Timber fit for Navy . . .	19,836	36,662	
	Defective oaks	1,743	3,835	40,497
1783	Timber fit for Navy . . .	12,447	19,827	
	Defective oaks	596	1,003	20,830

The Making of the Forest.

About the actual legal act of afforestation little need be said. It had nothing to do with forestry as we use the term to-day. Deer, like sturgeon, gold, and silver, were the King's prerogative. He made forests over the areas he wished to preserve for hunting. They included not only his own demesne land but also property belonging to his subjects. The management of the lands, whether the King's or the subject's, was directed towards the preservation of the deer. Not only were the deer themselves preserved, but the things they needed—vert great and small—which was broadly timber and underwood—were strictly reserved for cover, and land could not be enclosed so as to deprive deer of free run. These things came to be modified as the years passed, but they had a far-reaching effect on the silviculture of the area in three ways.

Firstly, the protection of vert undoubtedly checked the ruthless cutting of trees at a time when they would not be cared for otherwise. Secondly, Commoners' rights were created over the King's demesne. How that actually came about is a little obscure, but if a man grazed cattle on his own land (which he was entitled to do except in the fence month and during the winter heyning) and was not allowed to enclose his land, he could obviously not be held accountable if cattle strayed on to the King's demesne. In a sense too this privilege was a compensation for the disabilities placed on the subject's lands. As to the effect on the woods of the forest, enough has been said. The third result is less tangible but no less real. It was the outcome of the harshness with which they were enforced rather than the forest laws themselves. From the earliest days there has been a more or less organized opposition to the forest officers. This opposition has by no means always been unreasonable or detrimental in its effect. There is a contrariness about the history of actions and reactions in the forest which often brought results diametrically opposite to those their instigators desired. For instance, in the first half of the nineteenth century, in the face of opposition to the development of forestry, there was more than one determined effort by the administration to get the forest legally disafforested and enclosed which was killed by opposition. There can be little doubt that this saved the forest from the fate of several other forests which were disafforested about that time. None the less the opposition hampered the development of silviculture, tied the hands of the administration, and no doubt discouraged state forestry in this country in consequence for a very long time.

The Twelfth to Sixteenth Centuries.

We have little real information about the history of the forest during its first five centuries, but we can infer from a number of facts that it was a period of growing interest in sivilculture. The preamble to the first Forestry Act passed in this country in 1483 discloses that this movement was meeting with opposition from keepers whose solé interests were the deer. The practice of encoppicement which this Act sought to promote was directed to the preservation and systematic working of coppice, which was required chiefly for charcoal and fuel. Underwood was not the only consideration. The rules

which governed the working of the underwood provided for the encouragement and protection of the natural regeneration of the standards. From this we may infer that the heavy stocks of timber in the forest were already being cut into. Population was growing and more houses needed. Timber largely entered into their construction. More important, Britain was taking to the sea. Small shipyards along Southampton Water and the Solent were busy, and drawing their raw material from the forest.

The Sixteenth and Seventeenth Centuries.

This first Forestry Act was permissive. None the less that its provisions were put into effect is shown by the fact that a terrier of coppices compiled in the reign of Queen Elizabeth disclosed a total area of 5,800 acres so enclosed. That this was all that had been enclosed is very doubtful. The opposition of keepers was still very strong, and it is safe to infer that not a few copses had to be abandoned as a result of their depredations and others enclosed in their place. The more business-like instincts of the Tudors have secured us better records of their times. These take many forms but all disclose two things. Firstly, that the rapacity and dishonesty of the King's officers and the Commoners were largely defeating the objects of the many legal enactments and proclamations directed to the protection of timber. Secondly, there was a growing anxiety about the raw material of ships with which Englishmen were establishing England's naval supremacy abroad. From this anxiety there grew up the oak obsession which became so marked in the nineteenth century. Then beech and underwood were ruthlessly eliminated, with the result that areas which at one time carried magnificent oaks in a matrix of beech bear to-day pure crops of even-aged oak—stunted and many dying back—which are a problem. One would like to say more about this question of oak and beech. We assume too lightly because beech grows faster and is a shade-bearer it is bound to suppress the oak altogether. Oak in sound conditions is a doughty competitor, and it seems far more likely that on given soils and given conditions of these soils equilibrium is reached at a stage which in most cases falls far short of the complete elimination of the oak.

The policy of conservation initiated by the Tudors was maintained by James with characteristic vigour, but Charles had other preoccupations. A period of neglect set in which was intensified during the Civil Wars and Commonwealth and was scarcely relieved during the Restoration. What happened during that time can be judged by a comparison of the findings of the surveys of 1608 and 1707. Navy timber in the forest had literally been decimated. Enclosures had been thrown open and the numbers of Commoners' animals and deer largely increased. As a consequence, beech increased, and underwood largely disappeared and ash no doubt with it.

The Eighteenth Century and after.

The physical state of neglect into which the forest had fallen was bad enough, but the lawlessness which had grown up with it was worse. All efforts to enclose and replant were resisted. The situation could only be remedied by

Act of Parliament. The Act 9 & 10 William and Mary was passed to meet the situation. Under its provisions 2,000 acres were to be enclosed immediately and then 200 per annum for 20 years. As these woods became fit to be thrown open, another 6,000 acres were to be enclosed and planted in the same way. This statute marked a turning-point in the history of the forest. For the first time a limitation was set to the area which could be enclosed at any one time, and common rights received some form of statutory recognition. Another of its enactments was to make shrouding or pollarding of trees for browse a punishable offence. Opposition remained strong after the passing of the Act and its provisions were carried out only in a desultory way. About 1,022 acres were planted and looked after for 15 years, and then 50 years of neglect ensued. A further 230 acres were enclosed in 1750 and 2,044 more in 1776. It was a poor result of a great opportunity, but it was carried out in face of opposition from Commoners and keepers alike. The keepers were largely paid in kind—rabbits, right of turn-out of cattle (which was largely exercised in enclosures), and certain timber they regarded as their perquisites. They spent most of their time on their own pursuits, and thefts were rampant.

Two interesting points arise from the work done under this Act. The first was the method adopted in the early plantings. Plots were prepared about 2 feet square and 3 feet apart; in each 3 acorns were sown. After the acorns had been set the ground was broadcast with 'hawes, hollyberries, sloes and hazelnuts'. Mice were trapped and birds scared until the seed germinated. Up to some time between 1880 and 1890 some of these plantations had never been thinned, and a party of forest officers visiting this country from France pronounced them the heaviest stocking of oak they had ever seen. It is amazing that with this example of close stocking in the forest the process of over-thinning the younger woods should have been persisted in. The second point was the first introduction of pines into the forest in 1776. This was confined to two small clumps in Ocknell and Boldrewood, but it was destined to bring a great change in the forest and surrounding country. At first, it was used as a nurse for oak, but towards the end of the nineteenth century pure planting was resorted to on some of the poorer soils.

In 1789 the famous Commission which investigated the conditions of all the Crown forests reported on the New Forest. They put their finger on the two chief weaknesses of the administration—the divided control between keepers and forest officers, and the methods of payment. This was changed, and in 1808 an Act was passed re-enacting the main provisions of the Act of William and Mary. This confirmed the then existing enclosures of 2,274 acres, and authorized further enclosures up to a maximum of 6,000 acres at any one time. Under this Act 5,557 acres were planted between 1808 and 1817, and a further 1,471 acres between 1830 and 1848. The early plantings were mainly pure oak with belts and clumps of pine. In the later ones pine and larch were used as nurses.

Deer-hunting had then ceased to be a royal sport and the head of deer increased enormously, doing damage to private property and the enclosures and reducing the grazing for Commoners. What was known as the Deer

Removal Act was passed in 1851. In lieu of the right to keep deer the Crown was empowered to enclose 10,000 acres in addition to the 6,000 provided for in the previous Act. Though itself a compromise there were the seeds of further trouble in this Act. Less than 4,000 acres had been planted when a new agitation arose. The chief difficulty was the 'rolling power' which the Crown claimed to have to enclose and plant anywhere, but there was also strong feeling about the way in which Rackhamesque trees of the forest were rapidly being replaced by pines. The outcome of this agitation was the Act of 1877—the statute under which the forest is now administered. This limited the power to enclose to those areas which had been enclosed under the 1698, 1808, 1851 Acts, retaining the limit of 16,000 acres to be enclosed at any one time. To meet the aesthetic demands the following clause was inserted:

'That in cutting timber or trees for improving the woods, or for sale, care should be taken to maintain the picturesque character of the ground, and not wholly to level or clear the woods, but to leave from time to time a sufficient number of the most ornamental trees; and to keep the woods replenished . . . having regard to the ornamental as well as the profitable use of the ground.'

This clause was extraordinarily difficult to interpret. It was first taken to mean that on every acre cleared a certain number of old trees should be left. The result of this interpretation was the reverse to aesthetic and most unsatisfactory silviculturally. The old trees stood in a rising tide of young trees and gradually disappeared, leaving great holes in the plantations. Latterly a modification of the group system has been adopted which satisfies aesthetic and silvicultural requirements alike.

Nothing was done in the way of planting under this Act for about 25 years. In 1902 a working plan was prepared and re-enclosure started, but it was soon discovered that the old spirit of opposition was not dead. However, the War intervened and the heavy fellings (over 2,000 acres) which were necessary though regretted met with little opposition.

When the Forestry Commission took over in 1923 a new storm of opposition broke out. What happened then is too controversial to dilate upon. There was a new spirit abroad, however, and a *modus vivendi* was discovered in mutual accommodation. About 1,100 acres of the enclosurable woods are set aside for management as amenity woods. Over the rest of the enclosures subject to the 1877 Act and with due regard to general amenities the Commission retain full freedom.

CONCLUSION.

This sketchy account of the forest and its history has failed in its object if it has not at least indicated some of the more important problems with which its administration is faced. The space that remains leaves no room for further discussion of them and little enough for an account of how they are being approached.

The working plan divides the forest into three working circles—hardwood, coniferous, and aesthetic. The last-named is being worked with the help of an Advisory Committee appointed by the Forestry Commission. No definite

plan has been adopted yet, but the woods are being watched with a view to developing a system of natural regeneration by limited improvement fellings that will not materially alter the character of the woods. For the time anything done will be tentative. The area, 1,125 acres, is small, but what is done in it and the measures of success it attains is likely to have an important bearing on the future of some of the unenclosurable woods.

The apportionment of areas between the conifer and hardwood circles represents an attempt to assess the suitability of the soil to the two classes of trees. It will be seen from the table given earlier that it involves some conversion of conifers to hardwoods and vice versa, but there will no doubt be many revisions before finality is reached. The term hardwood has been adopted and represents a departure from the old oak obsession. Beech is being planted largely and small-scale trials are being made with other broad-leaved species, but oak still remains the principal species. In view of the general shortage in the country of oak of age-classes below 100 years, no attempt is being made to adjust the age-classes in these limits. The rotation for oak has been provisionally fixed at 150 years, but apart from natural regeneration work, fellings in this circle are confined at present to the cutting out of the least satisfactory of the 100 to 150 classes. This is being done in groups, and it is hoped that ultimately a systematic group system may be evolved which will meet all the requirements of the case. As opportunity offers the underplanting with beech of all the younger oak stands is being pressed forward. Over considerable areas where trespass by animals can be completely avoided the natural influx of beech is sufficient. All this will contribute to the elimination of grass from the enclosures.

In the conifer circle, fellings for the moment are confined to clearing belts left for shelter in the War fellings and now due for removal. It is intended to work the pines on a long (120 years) rotation. To do this, some protection of the soil will be necessary to avoid strong weed-growth as the trees open up. In the majority of cases there is a plentiful regeneration of beech where the soils are weed-free and the animals can be strictly excluded. It is hoped that the actual underplanting necessary will be small. Thinnings are being carried out with this object in view. A fair proportion of these thinnings are utilized as telegraph poles and dock piles, and large quantities as pit-props. While this work is in progress clear fellings are restricted. It is hoped ultimately that such areas as are to be retained under pines will be worked on a system of natural regeneration. There is and should be no difficulty about this. The soil is extraordinarily receptive to natural regeneration wherever grass is suppressed. In the avenue of trees which border the Ornamental Drive through Vinney Ridge there is a wide assortment of conifers, and below wherever light conditions suffice they are regenerating themselves freely. The soil there is quite typical of large areas in the forest. Undoubtedly the immediate and most important problems are, firstly, the securing of a proper soil cover, and, secondly, the question of drainage referred to earlier. When these have been solved, we will have to revise our earlier description of the soil as poor, at any rate so far as forestry is concerned, though many of the problems will remain.

Photograph by Davies, Lyndhurst

Two views of Salisbury Trench Enclosure showing the last stages of natural regeneration of oaks under the shelterwood system

PLATE I

PLATE II

Photograph by Davies, Lyndhurst

A group clearing in Burley New. These groups are arranged to open one into the other, so as to give vistas for aesthetic effect

DRUMMOND HILL

BY JOHN M. MURRAY

(Assistant Commissioner for Scotland, Forestry Commission)

INTRODUCTION.

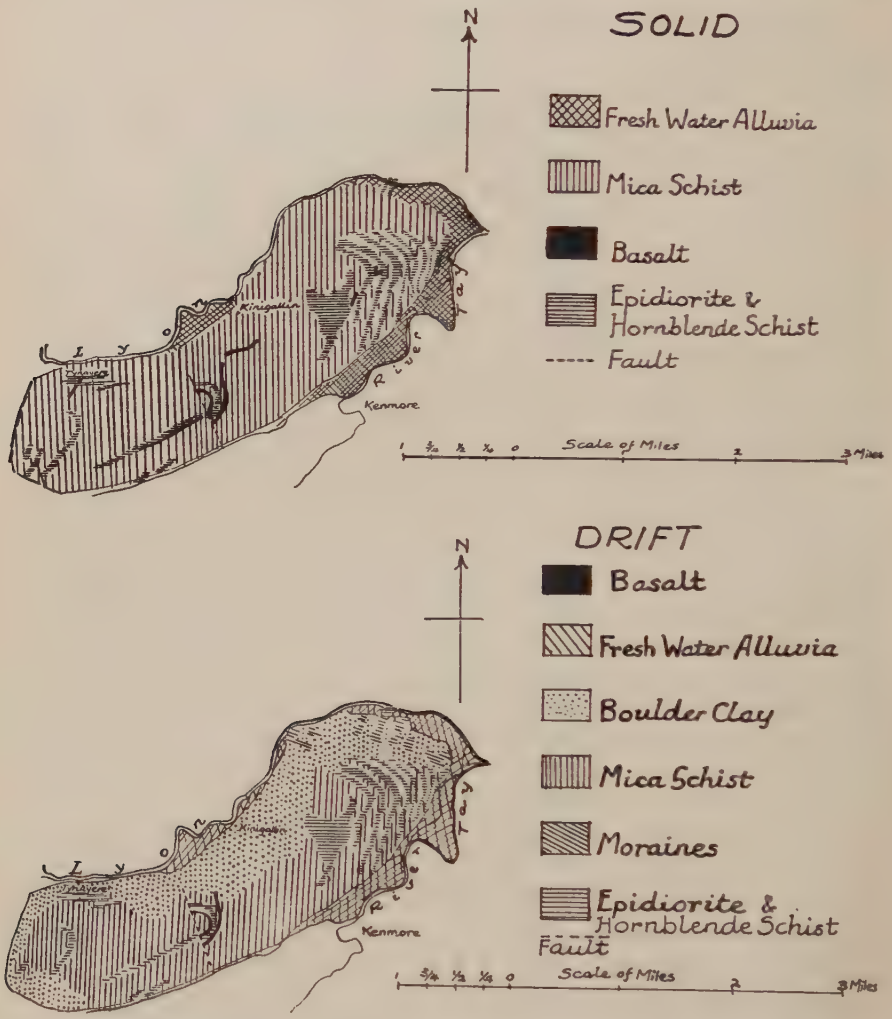
THIS area, extending to 2,513 acres, was acquired by the Forestry Commission in 1922. The origin of the name given to this hill in central Perthshire is somewhat obscure. Drummond, according to Johnstone, is derived from the Gaelic *dromainn* meaning 'a ridge'. The addition of 'hill' may have come as an anglicization of the name. There is the possibility, also, that since some of the lands in that district once belonged to the family of Drummond the name may have been derived from its owners. The most famous owners of the property, however, were the Campbells, Lords of Breadalbane. This family is descended from the western branch of the clan whose head-quarters were at Kilchurn, Loch Awe. Search of the family records, as printed in the *Black Book* of Taymouth, has failed to discover the date when the lands of Drummond Hill passed into their hands, but from inferences it appears to have been during the fifteenth century. It remained with them till 1922.

LOCALITY CONDITIONS.

The base of Drummond Hill is roughly oval in shape. It is bounded for over 3 miles on the south side by Loch Tay, and for 2 miles by the River Tay. The northern boundary is the River Lyon, and deep valleys separate it on the east and west from the neighbouring hill ranges. Drummond Hill, therefore, presents itself as an isolated hill, low compared with those around it, but bold in outline and arresting as a feature of the landscape. Its southern slopes are very steep, rising to 1,500 feet elevation, the elevation of Loch Tay being 380 feet. The northern slopes rise much more gradually, excepting at the north-western end where they become steep.

Situated near the centre of Scotland, Drummond Hill has a climate which is much less humid than the Forestry Commission areas of the west, and less cold than those of the east of Scotland. The average rainfall over five years is given as 36 inches. The precipitation is reasonably well distributed over the year. Snowfalls may occur during the months of December to March, but these are not so common as records indicate they were in bygone days. Except on the northern slope and at the higher elevations snow does not lie long. Frost may be severe, but early or late frosts are not common. Excepting the western end, the hill is moderately sheltered. Geologically, Drummond Hill is within the area in the Southern Highlands to which Sir A. Geikie gave the territorial name Dalradian. This territory was made up of a group of rocks which, in their general characteristics, were crystalline schists of a less gneissose type than those of the north-east. Drummond Hill is mainly formed of a silvery mica schist with occasional garnetiferous bands. In its lithological characters this approaches the better-known Ben Ledi schists, from which it is separated

by its stratigraphical position. This rock can produce a good soil, but the suitability of the country it occupies for cultivation in any form is extremely variable. Frequently, in this district, it is high-lying and exposed, but at its lower elevations it produces a very fertile soil on which, as on Drummond Hill,



some of the finest conifer timber in Scotland has been grown. Drummond Hill, on its northern and southern slopes, presents two rather different derivatives from this rock. From the evidence of the terminal moraines it appears that the hill was surrounded by the glacier that occupied the Tay valley and the lower reaches of the Lyon. The northern slope has been left with a glacial till, which is probably an agglomeration of the ground-down debris of the same rocks in the neighbourhood. Alien stones and boulders are very few. The till is mainly a rough, somewhat sandy but tough clay, frequently reddish-

brown, but sometimes grey or blue-grey in colour. Through it are scattered subangular, smooth, and striated stones of all sizes. The southern slope is different. Here and there, as near the eastern end, occur beds of glacial till, but in general the soil is of a much freer type. Considerable areas are covered by a deposit that appears to have been derived from the local rock by weathering. Over the greater part of the hill the soil covering is deep. Only on small areas of the northern slope, as at the Black Rock above Kenmore, and on some of the ridges to the west of this and above the service road, is the soil covering thin. On the northern slope there is a thin covering over rocks at the western end at an elevation of 1,100–1,200 feet in the part above where the Lyon turns directly eastwards. Another small area occurs near the eastern end. Parts of the ridge also are rather bare of soil. A small deposit of peat is formed in a basin at an elevation of 1,100 feet. If the areas of shallow soil are excepted, the southern slope may be described as being covered by a very high-grade forest soil. On the northern slope there are ridges of harder till that are more difficult to deal with, but generally the soil is of good quality.

The whole of the southern slope carried trees which have been felled since 1918. The vegetation covering it is therefore still in a transition stage. The first phase was a covering of grasses, mainly *Agrostis canina* and *Aira flexuosa* with colonies of *Pteris aquilina*. Since then the *Pteris* has spread and now is becoming dominant where planted trees do not smother it. The northern slope was not then covered and its vegetation probably approaches the normal climatic climax for the soil. It can be classed among the Scottish Heath Formations in which the *Calluna* has developed on a soil that is less moist than that of the Moor. *Calluna* here occurs, frequently with an admixture of *Pteris* and various grasses, as a band covering approximately half of the upper slope and projecting in long fingers into the lower belt of *Pteris* and grass. These fingers generally occupy the morainal ridges, and frequently cover a deep and free red loam. There is a small area of *Vaccinium Myrtillus* and *V. Vitis Idaea* near the eastern end. This occurs on a tight, leached clay, and the underground stems spread through a thin layer of peat. Another small local variation of some interest comes where the slope levels out at the edge of what is now cultivated land. Here and there springs have caused harmful erosion and there are left stream beds of packed clay and stones and islets of peat.

On this occurred *Drosera rotundifolia*, *Narthecium ossifragum*, tufts of *Calluna vulgaris*, *Juncus articulatus*, and *J. communis*. On the edges of the wash-out there was in some cases a much richer flora.

PREVIOUS HISTORY.

It has been mentioned that the southern slope was tree covered until recently. It was among the earliest planted areas in Scotland. Between 1583 and 1631 Sir Duncan Campbell planted a part near the eastern end. His wood was composed mainly of oak, birch, and Scots pine. He had considerable areas of natural forest of the last named on his estates, and from these he collected seed. Early in the eighteenth century about one-third of the slope

was planted, and between 1782 and 1805 the work was carried to the western end. In these operations the trees were planted to the highest points of the ridge. Small areas of the northern and western slopes were planted more recently.

The wood at the time of the compulsory acquisition of part of it was on the whole well although irregularly stocked. At the extreme eastern end the large, old hardwoods and larch were rather widely spaced, and at the western end much damage had been done by severe gales. In the eastern half, where planting had first been done, the percentage of beech was high. Through it were scattered large trees of European larch, Norway spruce, and Scots pine. Pure groups of pine occurred near the top of the slope, and these had sown seed on the adjoining treeless ground so that there arose a thin and rather branchy crop. Over the lower slope were scattered *Castanea sativa*, oak, sycamore, *Ulmus glabra*, and beech. The beech was of good height, but, having been grown openly, the number of first-rate clean boles was small. Many trees were so rough that the timber merchant left them standing. They proved a difficulty in replanting. Most of the oaks were of large size, and tall. The length of clean bole was relatively short in most cases, but the timber was of excellent quality.

The Scots pine that remained were tall and generally clean, but the beech had damaged the tops of many so that their development had been retarded. Norway spruces were tall, strongly branched and, on account of being overmature, the number of rotten stems was considerable. The best trees in this section were the larches. They were tall, clean, very large and with a few exceptions sound. Among them was the largest larch in Scotland. Its dimensions as measured by H. Watson and recorded by him in the *Transactions of the Royal Scottish Arboricultural Society* (vol. xxxviii, 1924, p. 145), were:

Age.	*Ht. to top. ft.*	*Ht. of timber. ft.*	*Average diam. of root. ft.*	*Contents Convertible timber. Q.G. cub. ft. U.B.*
150	110·9	101·6	6	724·2

The western section of the wood carried mainly conifers, larch, Scots pine, and Norway spruce with occasional beech trees in groups and single trees. The conifers were generally large, clean, and sound. The following Sample Plots figures taken in the eastern section indicate the development of the Scots pine (Forestry Commission Sample Plot figures):

No.	*Age.*	*Ht. ft.*	*Q.G. at 4–3 in.*	*Stems per acre.*	*Basal area per acre.*	*Form factor.*	*Vol. Q.G. U.B. per acre.*	*Crown %*	*Elevation of plot.*
1	137	79	16	170	300	0·423	10,025	39	1,050
2	136	75	13	235	273	0·453	9,265	27	1,050
3	125	78	15	185	288	0·384	8,630	45	850

Unfortunately no plots were taken of larch, but measurements made recently in a 20-years-old plantation indicate that it may be expected to reach Quality Class II.

It has been said that part of the wood was acquired by the Government. This extended to 676 acres and carried the following estimated volume of timber:

Species.	*Cub. ft. Q.G.*	*Remarks.*
Scots pine. .	402,587	Included 762 trees of average volume 96 cubic feet.
Larch . .	259,382	Included 774 trees of average volume 100 cubic feet.
Spruce . .	152,936	Included 710 trees of average volume 100 cubic feet.
Total	814,905	

In order that the ground might be cleared before the expiry of the time set for felling, trees were cut down much more rapidly than the sawmills could deal with them. A large area was covered with felled timber for three years. The conditions were perfect for breeding diseases. In other ways it was unfortunate that felling was done in such a wholesale manner. With careful adjustment of the felling programme the greater part of the area might have been regenerated naturally. Larch and beech would have produced a good crop of seedlings, but pine would have lagged. The conditions that succeeded the breaking of canopy, namely the growth of a dense mat of fine-leaved grasses, do not favour regeneration of pine in central Perthshire. It is doubtful also if Norway spruce would have produced many seedlings. It has been observed on Drummond Hill, as also in many parts of Scotland, that cones of spruce can be found on the trees and on the ground in early summer with the seed still in them. The question of place of origin of the seed for planting in various parts of Scotland deserves close attention if natural regeneration is to be expected in the future.

REAFFORESTATION.

In preparing for planting the main work was clearing brushwood. Very little draining was required, and no problems of an extraordinary kind were encountered. An attempt was made to reduce the cost of weeding by cutting tall bracken two or more years before the year of planting. It is doubtful if this procedure is advisable. The destruction, or partial destruction, of the bracken allows a strong growth of grass to come up. To protect newly planted trees from this may be more expensive than to protect them from bracken. In the allocation of species for planting it was kept in mind that the district is notable for the growth of larch, and it was desirable that all areas of suitable soil should be planted with that tree. The wet areas were excluded from consideration for larch. Broadly, there were then left the *Pteris* areas of good, free, well-drained soil; the *Calluna-Pteris* areas of free, well-drained glacial debris; the harder glacial knolls. There is evidence that the first and second of these types will grow good larch. There are no examples known in this

district of successful larch crops being raised on the third. In their general appearance knolls of the second and third types are very much alike. The third carries, however, an almost pure crop of *Calluna* (*Hypnum* spp. growing through it). The second carries a 'broken' *Calluna* crop. The associates are *Pteris* in single stems and groups, *Agrostis canina*, and other grasses. Failure to appreciate these distinctions led to certain small knolls of the third type being planted with larch. Replacement with pine had to be made later. Wet areas have been planted with Norway and Sitka spruces. Scots pine has been used on the hard knolls and dry sites.

An attempt has been made to introduce a sprinkling of beech by planting small groups among larch, and also a belt alongside the service road that had been made on the southern slope. In the first and second year's work this practice was not followed, but a small proportion of beech was brought in when beating up. On parts of the southern slope the number of beech seedlings that have sprung up is an embarrassment. They threaten to crowd out the larch, but with careful management they may be turned to excellent use.

In addition to the species mentioned above, there have been planted small areas of *Larix Kaempferi*, *Larix eurolepis*, *Tsuga heterophylla*, *Pseudotsuga Douglasii*, *Pinus Pinaster*, *P. silvestris lapponica*, *Abies alba*. These ought to form interesting plots in the future. Recently oak has been planted at the south-eastern end.

On Drummond Hill there are few disappointing patches. The small areas of hard till on which larch was planted in 1923 carry Scots pine which, although behind the rest of the crop, are healthy. Another small area of larch on a ridge of shallow soil is developing poorly. Generally growth has been good, although not so rapid as on certain favoured sites on the west coast. The following measurements show the rates of growth:

Species.	*Year of Planting.*	*Height average.* *ft.*	*ins.*	*Conditions.*
European larch .	1923	14	9	Drift soils of N. slopes.
Sitka spruce . .	1923	19	0	Drift soils of N. slopes.
European larch .	1924	15	6	Drift soils of N. slopes.
European larch .	1926	19	0	Weathered rock of S. slopes. Old Woodland.
Sitka spruce . .	1926	9	3	Weathered rock of S. slopes. Old Woodland.

The poorest growth occurs in Scots pine planted on rather shallow peaty soil near the north-west. Here the trees are unlikely to become large.

Larch and Scots pine planted in 1923 were seriously damaged by blackgame. The former had buds destroyed and tops and side branches cut off. Many plants were left like pruned sticks.

Buds of Scot pine were destroyed, and this damage sometimes affected considerable areas. This destruction caused more beating up than would normally have been necessary. Plants of larch on which a bud was left anywhere survived, and since the damage was not repeated so seriously in succeeding

years, the trees now show very little evidence of injury. The pines were damaged for several years, but they gradually grew beyond the reach of the birds. Later plantations of pine have all been retarded by blackgame, but the experience of the 1923 plantation encourages the opinion that recovery will be good.

Despite the dangerous clear felling practised in clearing the old wood no damage was done by insects or fungi.

ACQUIRED PLANTATION.

There was acquired with the land a plantation that is now 22 to 24 years old. This extends to 120 acres and carries a crop of European larch, Scots pine, Douglas fir, Sitka and Norway spruces. Cleaning and thinning have been carried out in practically all parts of this plantation and the stocking is fairly good in the larch, Scots pine, and spruces. Douglas fir suffered seriously from snow break and windfall, and portions had to be cut out. A small section of the larch had been planted on rather moist soil (carrying *Iris*) and the crop is rather thinner than in the better sites. Unfortunately the practice started by Sir Duncan Campbell of planting Scots pine grown from seed collected in the district had not been continued, and the alien pines tend to be less satisfactory. Many have broken or poor tops, and the branching is coarser than is desirable. The following measurements taken by the Forestry Commission's Research Branch indicate the growth in this plantation of Sitka spruce and European larch:

Species.	*Age.*	*No. of trees per acre after thinning.*	*Average ht. of crop.*	*Basal area per acre after thinning.*	*Vol. per acre U.B. cub. ft.*
European larch	20	1,010	32½	77·1	607
European larch	20	680	34	68·7	709
Sitka spruce	20	2,180	34½	183·3	2,083

Thinnings taken from this plantation have been sold for rustic wood and stack-props, and utilized for fencing-posts. A small consignment of pit-props was sent from the Sitka spruce thinnings.

NURSERY INVESTIGATIONS

BY JAMES MACDONALD

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I. THE USE OF SAND AS A COVERING MATERIAL IN SEED-BEDS

THE papers which follow give accounts of two investigations carried out by the Research Branch of the Forestry Commission in the nursery at Kennington, near Oxford. The papers are published with the kind permission of the Forestry Commissioners.

INTRODUCTION.

In a publication on 'Nursery Investigations' (1) Steven discussed the effect of conditions of tilth on germination in the seed-bed and paid attention both to tilth at the time of sowing and to the dangers of caking in the surface-layer of the soil after sowing had been completed. His experiments on the season of sowing brought out very clearly the importance of a good tilth, particularly with European larch and Sitka spruce, which showed themselves to be exceedingly sensitive to adverse conditions of this kind. The caking of the surface soil after sowing, which takes place in soils containing a fair proportion of silt, was also found to affect the germination to a serious extent. This caking, which generally follows after the soil has been beaten by heavy rain, leads to the formation of a thin but hard crust on the surface of the ground, and the conditions thus set up may prove to be highly injurious to germination. In order to prevent caking and generally to improve the conditions of tilth, Steven in 1925–7 carried out a series of experiments in which various possibly remedial treatments were tested on beds of Sitka spruce, European larch, and Douglas fir. The main object of these experiments was to discover some material which could be used to replace nursery soil and, when applied to the seed-beds by way of covering, would prevent surface caking and at the same time promote and improve germination. The experiments were carried out at Kennington Nursery and in the nursery at Bagley Wood near Oxford, the soil in the former being a sandy loam almost neutral in reaction and deficient in humus and in the latter a moderately acid loam containing a moderate percentage of humus. In each case covering with nursery soil was used as a control and the other treatments consisted of covering with coarse sand, with mixtures of humus and soil, and the application of lime together with soil in covering.

As a result of these experiments it was found that for Sitka spruce over three seasons and in both nurseries the use of coarse sand as a covering material gave the best results. It had a marked effect on the germination, which was greatly speeded up, and it led to the production of an appreciably larger number of plants. It was suggested that these improvements might have been connected

with improved aeration in the seed-bed as a result of the covering of sand and absence of surface caking. Improved results were also obtained in the beds of Douglas fir and European larch, but with Douglas fir the improvement was slight and the germination was not markedly accelerated. Lime with Sitka spruce and soil humus mixture with Sitka spruce and Douglas fir gave variable results, while there was little effect on Douglas fir with lime and on European larch with the soil-humus mixture.

The general conclusion arrived at, therefore, after this series of experiments had been completed was that coarse sand used as a covering material was of very considerable value in the raising of species such as Sitka spruce, which are easily affected by adverse conditions of tilth and are seriously hindered in germinating by the development of caking on the surface of the soil. So far as the use of sand was concerned, the results indicated above were quite conclusive and they had a considerable effect in influencing the practice in nurseries. Nevertheless, various additional experiments have been carried out since 1927 and further trials of sand coverings have been made, and it is now proposed to give a short account of this new work and to examine its results.

NEW EXPERIMENTAL DATA.

The experiments which are about to be described were carried out in 1930 and 1931 in Kennington Nursery, which is briefly described in the publication referred to at the beginning of this paper. The species dealt with were Sitka spruce, for which a continuation of the earlier work was considered necessary, birch and grey alder. In addition, the effect of sand covering has been tested, though not on an experimental scale, on seed-beds of Lawson cypress, *Nothofagus procera*, *Nothofagus obliqua*, *Pyrus aria*, and *Pyrus intermedia*. The sand which was used in the experiments was a coarse, gritty Bedford sand, well washed and as free from silt as possible. It is of great importance that the sand should be free from silty matter as, if this is present in any quantity, caking of the surface may result. (See p. 41 for analysis of sand used.)

The results of the different experiments are given below.

Experiment 1, 1931. *Sitka Spruce.*

In this experiment the following treatments were carried out and compared:

A. Control. Covering with nursery soil.
B. Covering with coarse sand.
C. Covering with well-decomposed broad-leaved humus.
D. Covering with well-decomposed litter from a stand of Douglas fir.
E. Covering with well-decomposed litter from a stand of *Tsuga heterophylla.*

There were four replications of each treatment arranged in Randomized Blocks. The seed was sown in drills on 25 and 26 March 1931 under favourable conditions, and the first seedlings appeared on 7 May in the plots covered with sand. In this treatment the germination was completed by about the end of May while at this time it was only beginning in the plots covered with nursery

soil, broad-leaved humus, and coniferous litter. In these plots the germination was not completed until the end of June. The effect of the sand covering is brought out well by Table I, which gives the number of seedlings counted in sample drills at different dates during the summer.

TABLE I. *Experiment* 1, 1931. *Sitka Spruce.*
Average number of seedlings per drill (3 *feet*).

Date.	*Treatment.*				
	A.	*B.*	*C.*	*D.*	*E.*
2 June 1931 . .	24	146	11	25	22
30 June 1931 . .	97	155	53	61	51
28 September 1931 .	90	143	48	56	46

The figures show clearly the great effect of the sand covering in speeding up the germination. Little further germination took place in this treatment after the beginning of June, but in the other treatments it was developing actively during that month. The effect of the sand on the yield is also striking, and the production with this treatment has been very much higher than that obtained with the other methods of covering. The relatively poor yields with the humus and litter coverings may be partly accounted for by the way in which these forms of covering were disturbed by strong winds which during April occasionally removed part of the covering material and exposed the seed.

The seedlings in this experiment were lifted at the end of their second season in the seed-beds, graded, and counted. The number of usable plants produced per sampling unit of 7 drills was as follows:

Treatment.					*Standard error.*	*Difference required to give a* 20 *to* 1 *probability of significance.*
A.	*B.*	*C.*	*D.*	*E.*		
474	885	288	296	238	±54·7	174·1

The number of seedlings per square yard (drill sown) in each of the treatments when the plants were lifted was as follows:

A	468	B	872
C	283	D	291
	E 234		

The highest production (B) was equivalent to a yield of 58,000 seedlings per pound of seed sown.

The results of the final counts in this experiment confirm the figures which were obtained during the first season. The yields were high, particularly with the sand covering and to a less extent with the covering of soil, and this was due to a considerable extent to the favourable weather conditions during the first season.

Experiments 4 *a and* 4 *b*, 1931. *Sitka Spruce.*

The main object of these experiments was to test the effect on the growth of seedlings of Sitka spruce of applications of artificial manures before sowing. As, however, the seed-beds in Experiment 4 *a* were covered with sand and those in 4 *b* with broad-leaved humus, it is possible to make use of the data in order to obtain a comparison between these two methods of covering. Fortunately the experiments were laid down side by side and there were no local conditions of such a kind as to invalidate a comparison between them. Only the unmanured sections of the two experiments will be compared and discussed.

The seed was drill sown on 22 April 1931, and germination began on 21 May in the sand-covered experiment (4 *a*) and about a week later in the section covered with humus. The progress of the germination during the first season is indicated by the data in Table II.

TABLE II. *Experiments* 4 *a and* 4 *b*, 1931. *Sitka Spruce.*
Average number of seedlings per drill.

Date.	4 *a.* *Sand covering.*	4 *b.* *Humus covering.*
4 June 1931 .	178	37
29 June 1931 .	217	160
2 October 1931 .	191	142

These figures confirm the results of Experiment 1, for they show that sand has once more had a marked effect in hastening the germination. With a covering of broad-leaved humus the germination proceeded much more slowly and the production of seedlings was not so high.

At the end of the second season the plants were lifted as 2-year seedlings and then graded and counted. The number of fit plants per drill with sand covering was found at the time of lifting to be $164 \pm 7{\cdot}1$ and with humus covering $126 \pm 7{\cdot}7$. The advantage of covering with sand as compared with humus is thus confirmed by the counts at the end of the second year. The yield of seedlings in this experiment was considerably higher than in Experiment 1.

Experiment 31, 1930. *Birch.* (Photograph 1.)

The following treatments were carried out in this experiment:

A. Birch seed covered with nursery soil.
B. No covering. Seed pressed into the soil.
C. Covering with coarse sand.
D. Covering with broad-leaved humus.
E. Covering with a mixture of sand and broad-leaved humus.
F. Covering with coarse sand as in C. The soil in this treatment, however, was made up into a mixture of broad-leaved humus and nursery soil.
G. Covering with a mixture of sand and hardwood ashes. There were three replications of each treatment in Randomized Blocks.

The seed was sown broadcast on 10 May 1930, and germination was general in treatments C and F by the second week in June. In the other treatments the germination was much slower in beginning and the germinating seedlings appeared to suffer during a spell of dry weather in June, with the result that the crop in those treatments was poor and patchy. Table III gives details of the germination based on counts of seedlings on three different occasions.

TABLE III. *Experiment* 31, 1930. *Birch.*
Average number of seedlings per square yard.

Treatment.	*17 June 1930.*	*16 July 1930.*	*17 September 1930.*
A	108	132	108
B	36	54	24
C	2,664	3,546	2,736
D	48	42	30
E	324	414	324
F	3,180	3,336	2,040
G	144	234	180

This table shows the remarkable effect of using sand as a covering for seed-beds of birch. It should also be noticed that the treatment in which sand was used in mixture with humus is better than that in which the humus was used alone. This and treatment B where no covering was used are exceedingly poor, but a good deal of the seed was blown away and the low production is partly the result of this accident.

The plants were lifted as 1-year seedlings at the end of the first growing season and, after grading, were counted. The number of usable plants per square yard in each of the treatments was as follows:

A	55	D	17
B	20	E	116
C	1367	F	1798
	G 79		

Standard Error . ±176·7
Difference to give a 20 to 1 probability of significance 760·3.

These figures represent a production per pound of seed of 220 for A, 100 for B, 5,500 for C, 75 for D, 450 for E, 7,200 for F, and of 320 for treatment G.

Experiment 34, 1930. *Grey Alder.* (Photograph 2.)

This experiment was similar to No. 31, but the sowing was carried out two days earlier. The behaviour in the early stages and throughout the first year resembled very closely that of the birch in Experiment 31, as may be seen from Table IV.

The dense crops produced by the coverings of sand and the low production with other methods of covering are again a striking feature.

TABLE IV. *Experiment* 34, 1930. *Grey Alder.*
Average number of seedlings per square yard.

Treatment.	*17 June 1930.*	*16 July 1930.*	*17 September 1930.*
A	120	114	90
B	54	42	30
C	2,310	2,472	2,256
D	186	198	156
E	234	204	216
F	3,918	4,464	3,546
G	318	312	282

The numbers of usable 1-year seedlings produced per square yard in each of the treatments at the end of the first season were as follows:

A	32	D	33
B	9	E	59
C	666	F	1032
	G 58		

Standard Error ± 120·15.
Difference required to give a 20 to 1 probability of significance 518·2.

The yield per pound of seed was 350 for treatment A, 100 for B, 7,500 for C, 360 for D, 750 for E, 11,500 for F, and 250 for G.

Other Species.

As has already been mentioned, sand has been tested as a covering material, though not with proper experimental technique, against nursery soil on species such as Lawson cypress (Photographs 3 and 4), *Nothofagus obliqua*, *N. procera*, *Pyrus aria*, and *P. intermedia*. In each case it has given very much better results than soil as regards both number of seedlings and size of plant.

CONCLUSIONS.

The new experiments which have been carried out with Sitka spruce confirm fully the earlier work which has already been described. The advantages which are obtained with sand are, in the first place, the speeding up of the germination, and secondly, the production of a larger number of plants. Rapid germination means that the seedlings have the benefit of a longer growing season, while the uniform germination which follows the application of a sand covering results in the production of a crop of seedlings all of which have a good chance of developing. When germination is spread out over a considerable period, the seedlings which come up towards the end of the period do not have a good prospect of developing into useful plants because they are generally suppressed or crowded by the more vigorous plants which germinated earlier. In this way, with prolonged and irregular germination, a large number of the seedlings have to be rejected on account of their small size and weakly character, and the output of usable plants is materially reduced. To obtain rapid

germination is also of importance when sowing has had to be carried out late in the season, and in a case of this kind the use of sand cannot fail to be of service.

The improved production which results from the use of sand in covering is due to the prevention of caking of the surface soil and no doubt also, as has been suggested, to the improved aeration in the seed-beds.

With birch and grey alder germination is likewise hastened by sand coverings and the production increased. The difference with these species is much more strongly marked than with Sitka spruce, and it is really a difference between success and more or less complete failure.

The photographs (Nos. 3 and 4) show very clearly the improvement obtained with sand in beds of Lawson cypress, and it is not unlikely that for similar species, *Thuja*, &c., sand will prove of great benefit.

The other types of covering which have been tried, humus, litter, &c., have not given satisfactory results. The fact that coverings of this kind are so easily disturbed and even removed by wind is ufficient to prevent their use in general practice.

Literature References.

(1) Steven, H. M.: *Nursery Investigations*. Forestry Commission Bulletin No. 11, 1928.

II. STRATIFICATION AS A MEANS OF IMPROVING THE GERMINATION AND PRODUCTION OF SEED OF DOUGLAS FIR

INTRODUCTION.

Experimental work carried out some years ago in this country showed that the nursery treatment of Douglas fir offers for solution some interesting and important problems. The principal difficulties are met with in connexion with germination. With normal sowings of this species in the spring it is found that germination is irregular and apt to continue over a relatively long period of time, while, particularly in sowings made in the late spring, many of the seedlings may lie dormant over winter and germinate only in the second season. This behaviour is not uncommon among tree seeds, as it has been recorded for numerous important species and much experimental work has been done in attempting to find a remedy. The cause of this phenomenon does not seem as yet to have been fully explained; it may lie, as has been suggested, in some peculiarity of the seed-coat, rendering it more or less impermeable, or it may be due to the need of the embryo for some process of development or 'after-ripening' after the seed has been shed. On the other hand, it is undoubtedly connected to some extent with climatic and tilth conditions after sowing.

The earlier experiments which were carried out in Great Britain (8) showed very clearly that by means of early sowing, i.e. in December, January, or February, a great improvement in production could be obtained, and it was

established that the amount of delayed germination increased as sowings were made later. These conclusions are in agreement with the results of Wahlenberg's work with *Pinus monticola* (11) in the United States, and they are supported in Germany by Bütow (3), who recommended autumn sowing for Douglas fir. But early sowing as advocated in this country, and particularly autumn sowing in September as recommended by Wahlenberg, raises some important practical difficulties. It is rarely possible at these early dates to obtain ground for making up seed-beds as the areas are generally still occupied by the previous season's plants, while weather conditions may be quite unsuitable for seed-bed preparation or for sowing. In addition, seed sown in the autumn or winter generally requires special protection from mice and other vermin, and there is the further disadvantage that weeds develop early on early-sown beds (Photograph 1) and extra costs are incurred in this way. So far as we in Great Britain are concerned, really early sowings can only be made with old seed because the seed of the current season does not arrive from Western America in time to permit of sowing much before February. It will be seen, therefore, that although there are advantages in early sowing, there are at the same time serious practical objections to this method of treatment which make it necessary to seek some other solution of the problem.

One form of treatment which has been employed experimentally, on the assumption that it is the impermeability of the seed-coat which is responsible for the delayed germination, is soaking in acid of different strengths for longer or shorter periods. Thus Larsen (7) working with *Pinus monticola* found that the best method of dealing with this species was to immerse the seed for 45 minutes in a concentrated solution of sulphuric acid and then rinse thoroughly in water. On the other hand, Tozawa (10) in Japan found that acid treatment with the seed of *Pinus koraiensis* was not altogether satisfactory, while Jacobs (5) in the United States obtained rather contradictory results with *Pinus lambertiana*. Mechanical abrasion of the seed-coat was found by Larsen to help the germination of *Pinus monticola*, but there are obvious dangers in a method of this kind.

Exposure of the seed to the temperature of melting ice for different lengths of time was found by Johnstone and Clare (6) to be effective in speeding up the germination of various species of pine, and Larsen found that soaking the seed of *P. monticola* in cold water for 24 hours before exposing it to freezing in the open air also gave reasonably good results. Tozawa successfully dealt with numerous Japanese species by two methods of cold moist storage which he called respectively 'exposed burying storage' and 'protected burying storage'. In the former the seed was mixed with moist sand in a container which was let into the ground only deep enough to being the top level with the surface of the soil. No covering was applied, and the seed was thus more or less fully exposed to the weather during winter. This method of storage, he found, gave rather better results than his 'protected burying storage', in which the seed mixed with sand was stored in containers buried in the ground, except that there was a tendency with some species to germinate

in storage during mild weather. This did not happen in the 'protected' storage (which is really the same as stratification), and he therefore recommended this treatment for some of the more sensitive species.

The method of storage and treatment of seed by stratification has been investigated principally by the staff of the Boyce Thompson Institute for Plant Research in the United States, and a good general account of this type of work has been given by Crocker (4). In the original form of this treatment the seed was placed in layers in a container alternating with layers of the stratifying medium, peat, sand, &c., and the whole kept at a low temperature, generally in a pit sunk in the ground. Instead of stratification in the strict sense, in layers, Crocker recommends a uniform mixture of seed and medium, and as a medium he prefers an acid granulated peat to sand. He states that in order to obtain the best results from this treatment there should be a proper regulation of water and air supplied. There should be no water-logging nor, on the other hand, should drying out be permitted, while the mass of seed and medium should be kept loose so that there is always a good air supply. He finds that temperatures of between 32° F. and 50° F. are the most satisfactory. Stratification in this way has been found by Barton (1 and 2) to be effective with the seed of a large number of conifers, including many of economic importance.

In view of the fact that Douglas fir had not been included among the species dealt with in any of the communications referred to above, it was decided to test the method with this species. Accordingly, a series of experiments was commenced in 1932 at Kennington Nursery, Oxford, and was continued during 1933 and 1934. The results described below show that stratification does in fact represent a very considerable advance in the nursery technique of Douglas fir.

METHODS OF PROCEDURE.

(*a*) *Media.* In the experiments only two media have been employed—peat and sand. The sand was the coarse Bedford sand used for covering seed-beds, while the peat was an acid amorphous peat obtained near Beddgelert, Carnarvonshire. The peat, which was dug from the bottom of an open drain, was allowed to weather before being used.

(*b*) *Method of Stratification.* Before this series of experiments was commenced, several preliminary trials of stratification were made with seed of various species. To begin with, the seed was stratified in the strict sense, that is, it was placed in layers between layers of sand or peat, and although in some cases this method served well enough, in others it led to mouldiness and decay in the seed. Consequently, it was decided to try a uniform mixture of the seed and medium as recommended by Crocker. This method was found to be much more satisfactory and was used subsequently in all the experimental work. The mixture of the seed with the stratifying medium was made in the proportion of 2 parts by volume of seed to 3 parts of the medium. The mixture

was pressed firmly into 8-inch unglazed earthenware flower-pots which were used as containers.

The storage of the seed during stratification was carried out in two different ways. In two of the experiments the flower-pots with the mixture of seed and sand or peat were placed at a depth of about 18 inches in a specially prepared pit and were covered with the medium which happened to be used until the pit was filled. The pit was excavated to a depth of about 24 inches and was lined and covered with fine-meshed wire netting to protect the seed from mice, while in order to promote drainage and prevent water-logging a layer of sharp stones and broken earthenware was placed at the bottom. This method is similar to that of stratified storage employed in the United States and it corresponds to Tozawa's 'protected burying storage'.

In the remainder of the experiments the flower-pots were sunk in the ground until the tops were level with the surface (Photograph 6). This method of treatment is not unknown in horticulture (9) and is similar to Tozawa's 'exposed burying storage'.

During the period of stratification the seed was examined at regular intervals in order to see that the moisture conditions were satisfactory, and towards the end of the period a close watch had to be kept for signs of germination. Examination of the seed in the pit was much more difficult than in the flower-pots at ground level.

(*c*) *Duration of Storage under Stratification.* Two periods of stratification were studied, a long period lasting for about 100–120 days and a short period of 60–70 days.

(*d*) *Dry Storage of Seed.* The seed which was kept in hand for the shorter period of stratification and for sowing in spring was stored dry in glass Kilner jars with airtight metal tops. These jars proved both satisfactory and convenient for the relatively small quantities of seed which were being dealt with.

(*e*) *Method of Sowing.* No attempt was made at the time of sowing to separate the seed from the medium in which it was stored, and in practice the mixture was sown broadcast. The effect of adding the medium to the seed-bed with the seed was not studied. Since the beds were covered with sand after sowing the addition of sand with the seed could not affect the conditions, while it seemed unlikely that the relatively small amounts of peat added to the seed-bed could make any serious difference.

WEATHER CONDITIONS.

During the winter of 1931–2 temperatures were average and rainfall normal, while during the summer of 1932 there was abundant rainfall without excessively high temperatures and consequently no damage by drought in the seed-beds. During the winter of 1932–3 there were several periods of low temperature, but the rainfall was about the average; in the late spring and summer of 1933, however, conditions were unfavourable as temperatures were high and the rainfall slight. 1934 resembled 1933 in that the winter temperatures were low and the summer warm and dry and unfavourable to germination. Drought

conditions in 1934 were made worse by the abnormally low rainfall during the previous winter. Rainfall over the 6 months, April–September 1932, amounted to 16·28 inches, for the same period in 1933 to 9·58 inches and in 1934 to 8·73 inches.

TEMPERATURES DURING STRATIFICATION.

During stratification the temperatures in the soil and medium were taken by a recording thermometer. It was found that there was little difference in temperature between the sand and the peat, but temperatures in the latter were very slightly higher. In the pit, the temperatures were recorded at a depth of 18 inches and were found to vary little, such changes as occurred being very gradual. The range was narrow, lying between 32° F. and 41° F., and even at the end of the period, when the air temperatures were up to 70° F., there was only a gradual increase in the pit. In the same way the temperature in the pit never fell below freezing-point, although several sharp frosts were experienced.

On the other hand, in the flower-pots plunged in the soil, where the readings were taken at a depth of 6 inches, there were marked fluctuations and, except in the very coldest weather, pronounced diurnal variations were observed. The range of temperature was much wider and extended from 24·5° F. to 49·5° F., and towards the end of the period the diurnal variations were strongly marked. It was found that when the seed was stored in this way it was much more advanced and in some cases germination had begun, whereas in the pits there was no sign of its commencement.

In Fig. 1 charts are given showing the variations in temperature over one

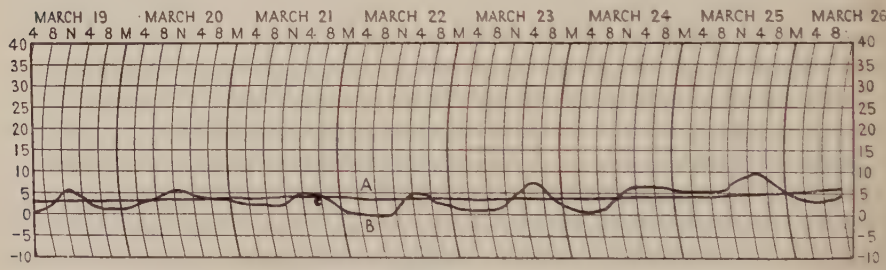

Fig. 1.

week (19–26 March 1934) among seed stratified in sand in the pit at 18 inches below ground (A) and in flower-pots 6 inches from the surface of the soil (B). This diagram brings out very clearly the diurnal variations in the second method of storage.

DESCRIPTION OF EXPERIMENTS.

Experiment 46, 1932.

In this experiment two different media—sand and peat—were used, and the seed was subjected to two periods of stratification of different length. Stratification was carried out in the pit.

The following treatments were employed, and there were four replications of each arranged in Randomized Blocks.

(*a*) Early sowing on 8 December 1931.
(*b*) Seed stratified in peat on 8 December 1931 and kept under this treatment for 127 days. Sown on 13 April 1932.
(*c*) Seed stored dry until 30 January 1932, when it was stratified in peat for 74 days. Sown on 13 April 1932.
(*d*) As for treatment (*b*), but stratification in sand instead of peat.
(*e*) As for treatment (*c*), but stratification in sand instead of peat.
(*f*) Spring sowing of dry stored seed on 13 April 1932.

When removed from stratification the seed was in good condition but there was no germination. By the 11th of May germination was general in the plots of treatment (*a*) and was just commencing in (*b*), (*c*), and (*d*), but in treatments (*e*) and (*f*) there was no sign of germination on this date. By the middle of June germination in treatments (*a*)–(*e*) appeared to be complete, but in (*f*) it was still going on and it continued in this treatment until the beginning of August. The following figures, which give the average number of seedlings per $3\frac{1}{2}$ square feet of seed-bed on two different dates during the summer, show how the number of plants in the spring-sown plots was still increasing, whereas in the early sowings it was stationary or decreasing slightly.

Number of seedlings per 3·5 sq. feet.

	December sown (*a*).	*Spring sown* (*f*).
18 July 1932	305±29·51	183± 7·09
31 August 1932	273±25·89	238±10·11

An assessment of the number of seedlings in each of the sections was made on 18 July, and the details are given below.

Number of seedlings per sample strip 3·5 sq. feet.

Treatment.					
(*a*)	(*b*)	(*c*)	(*d*)	(*e*)	(*f*)
305	0	179	9	346	183

Standard error mean of 4 plots . . ±44·2.
Difference required to give a 20 to 1 probability of significance 140·64.

At the end of the first growing season the plants were lifted as 1-year seedlings, graded, and counted. The grades which were recognized were: 1. Good plants 6 inches and over. 2. Good plants 4–6 inches in height. 3. Good plants under 4 inches. 4. Culls; defective and very small weakly seedlings. The data obtained from the counts are summarized in Table I.

Production of usable plants per pound of seed: 24,3000 early sown; 18,700 spring sown; 28,600 short stratification in sand.

TABLE I. *Experiment* 46, 1932.

Grade.	*Number of seedlings per square yard in treatments.*					
	(*a*)	(*b*)	(*c*)	(*d*)	(*e*)	(*f*)
1	65	0	14	1	13	1
2	257	1	157	7	191	105
3	407	0	317	9	655	455
Culls	22	0	16	1	37	55
1–3 (good plants)	729	1	488	17	859	561
Total	751	1	504	18	896	616

These results are interesting. Two treatments, (*b*) and (*d*), in which long periods of stratification in peat and sand respectively were tried, proved almost complete failures, while the highest yield was given by the short period of stratification in sand with the early sowing treatment as a close second. A short period of stratification in peat gave moderately successful results, while the spring sowing was also fairly satisfactory. In connexion with the last mentioned treatment, it is interesting to note that during the favourable growing season in the summer of 1932 the yield was well maintained, although it remained considerably smaller than that obtained by early sowing or by a short period of stratification in sand. It should be noted that in the three most successful treatments the proportion of Grade 1 seedlings was highest in the early sown beds and lowest in the beds sown in spring.

Experiment 60, 1933.

This was the only experiment to be carried out in 1933, and it was simply a repetition of the previous year's work except that stratification was carried out in flower-pots sunk into the soil at ground level.

The early sowing was carried out on 22 December 1932, and the spring sowing on 5 April 1933. The long period of stratification in peat and sand lasted from 22 December to 5 April (104 days) and the short period from 30 January to 5 April (64 days). All the stratified seed was sown on 5 April 1933, and this relatively early sowing date was chosen because germination was just beginning in the stratified seed.

Germination began in the early sown seed-beds on the 7th of April and was general in this section of the experiment by the end of that month, when germination was just commencing in treatments (*b*), (*d*), and (*e*). There was no sign of germination on 28 April in either treatment (*c*) (short period of stratification in peat) or (*f*) (spring sowing).

By the end of May germination was complete in the early sown beds and practically complete in treatment (*e*) (short period of stratification sand). In the spring sowings germination was only beginning and it continued intermittently in this section until 24 August. Treatment (*c*) (short period of stratification in peat) proved almost a complete failure, while treatments (*b*) and (*d*) were variable and on the whole poor. An assessment carried out in

July gave an impression of the early development of the various sections in the experiment. The results were as follows:

Number of seedlings per sample strip 1·5 *sq. feet.*

Treatments.					
(*a*)	(*b*)	(*c*)	(*d*)	(*e*)	(*f*)
152	71	1	18	150	33

Standard Error . . ±9·86.

Difference required to give a 20 to 1 probability 31·377.

The plants were lifted after the first season's growth and graded as 1-year seedlings as follows: Grade 1, good plants 3 inches in height and over. Grade 2, good plants less than 3 inches. Grade 3, culls; defective and very small plants. The number of seedlings per treatment in each of the grades was counted and the figures are summarized in Table II.

TABLE II. *Experiment* 60, 1933

Grade.	*Number of seedlings per square yard in treatments.*					
	(*a*)	(*b*)	(*c*)	(*d*)	(*e*)	(*f*)
1	315	247	3	91	393	49
2	315	131	1	11	269	68
Culls	85	47	0	3	79	41
1–2 (good plants)	630	378	4	102	662	117
Total	715	425	4	105	741	158

The production of usable 1-year seedlings per pound of seed was 21,000 for the early sowing, 3,900 for the spring sowing, and 22,000 for the short period of stratification in sand.

This experiment confirmed the result of the previous year's investigations in some respects, but in others there were well-marked contrasts. It showed that early sowing and the short period of stratification in sand are the most successful treatments, and on this occasion these methods stand out very much more distinctly from among their rivals. Spring sowing, which in 1932 gave relatively good results, was very much poorer in 1933, and this result is undoubtedly due to the dry conditions which were experienced in the second year. The treatments with peat have given completely contradictory results. In 1932 the short period of stratification gave a fairly good figure while the long period led to complete failure; in 1933 the short period treatment failed while the long period gave moderately good results. It is difficult to account for these contradictory data. The other treatment—prolonged stratification in sand—led to almost complete failure last year and on this occasion to a slightly better but still poor out-turn of plants.

1934 *Experiments.*

The work carried out during 1932 and 1933 showed that peat was an uncertain medium for stratification, and accordingly in the plans prepared for

1934 it was decided to drop this form of treatment and to concentrate on sand. In spite of the poor results obtained from prolonged stratification in sand it was decided to give this method another trial. Four methods of treatment were proposed as follows:

(*a*) Autumn sowing.
(*b*) Prolonged stratification in sand.
(*c*) Short period of stratification in sand.
(*d*) Spring sowing.

Unfortunately, owing to the late arrival of the seed, the plan had to be modified, treatment (*b*) being abandoned and the sowing in treatment (*a*) carried out at the end of January instead of the autumn.

Two methods of stratification were studied. In Experiment 76 the seed was stratified in the pit at a depth of 18 inches, and in Experiment 77 in flower-pots plunged into the soil at ground level.

Experiment 76, 1934.

Three treatments were carried out: (*a*) early sowing on 29 January 1934; (*c*) stratification in sand from 30 January to 12 April (72 days) when the seed was sown; (*d*) spring sowing on 12 April 1934. The sowing units in this experiment were laid out in Randomized Blocks with four replications of each treatment.

On 12 April, when the seed was taken from the pit for sowing, no germination had taken place but the individual seeds were plump and in good condition.

Germination in treatments (*a*) and (*c*) was complete by the middle of June, but with the early sown seed it took place in two distinct stages, the individual seedlings in consequence varying considerably in size in the plots of this treatment. In the stratified section germination took place in one stage and there was no second germination. In treatment (*d*) (spring sowing) germination by the middle of June was by no means complete and it went on intermittently until the end of August.

A count of seedlings in July gave the following results:

Number of seedlings per sample strip (1·5 *sq. feet*).

(*a*) *Early sowing.*	(*c*) *Spring sowing. Stratified.*	(*d*) *Spring sowing. Dry stored.*	*Standard Error.*	*Difference required for a 20 to 1 probability of significance.*
65·5	96·0	13·25	±4·281	13·622

These figures show that stratification gave significantly better results than early sowing and very much better results than spring sowing.

At the end of November 1934, the seedlings were lifted and graded as follows:

Grade 1. Good seedlings, over 3½ inches tall.
Grade 2. Good seedlings, 3½ inches and under.
Grade 3. Culls; defective and very small seedlings.

Table III gives the result of the assessment of the graded seedlings and is based on a count of all the plants.

TABLE III. *Experiment* 76, 1934.

Number of seedlings per square yard.

Grade.	(*a*) *Early sowing.*	(*c*) *Spring sowing. Stratified.*	(*d*) *Spring sowing. Dry stored.*
1	159	265	11
2	216	367	30
Culls	34	62	35
1–2 (good plants)	375	632	41
Total	409	694	76

The production per pound of seed was 12,500 for the early sowing, 1,400 for the spring sowing, and 21,000 for the stratified seed.

This table brings out very clearly the remarkable effect on the germination of Douglas fir of a short period of stratification in sand. The early sowing has given satisfactory results, but in this experiment the out-turn of plants from this method of treatment is smaller than that from the stratified seed. The normal spring sowings in comparison have led to deplorable results, and these sections of the experiment suffered badly from the drought; the prolonged and irregular germination in the seed-bed which is a consequence of dry storage and spring sowing is ill adapted to weather conditions of a summer such as that of 1934.

Experiment 77, 1934.

This experiment was similar to No. 76 except that the seed was stratified in flower-pots plunged into the soil, and the various operations were carried out on the same dates.

At the end of the period of stratification many seeds were found to be germinating, and conditions in this treatment generally were slightly more advanced than in the corresponding treatment of Experiment 76, but after sowing there was little difference between the experiments. Germination of the stratified seed was completed rapidly, that of the early sown seed less rapidly and in two stages, while the spring sowing of dry stored seed was again a comparative failure.

A count of seedlings in the beds at the end of July gave the following results:

Number of seedlings per sample strip (1·5 *sq. feet*).

(*a*) *Early sowing.*	(*c*) *Spring sowing. Stratified.*	(*d*) *Spring sowing. Dry stored.*	*Standard Error.*	*Difference required for a* 20 *to* 1 *probability of significance.*
55·3	95·5	7·5	±10·66	33·912

These figures are similar to those obtained in Experiment 76.

As in Experiment 76, the seedlings were lifted in November 1934, graded in the same way, and counted. The details of this assessment are given in Table IV.

TABLE IV. *Experiment 77, 1934.*
Number of seedlings per square yard.

Grade.	(*a*) *Early sowing.*	(*c*) *Spring sowing. Stratified.*	(*d*) *Spring sowing. Dry stored.*
1	113	214	2
2	216	431	17
Culls	23	44	32
1–2 (good plants)	329	645	19
Total	352	689	51

Production per pound of seed for the early sowing was 11,000, for the stratified seed 21,500, and for the spring sowing 650.

This table offers further evidence of the beneficial effect of a short period of stratification in sand and confirms generally the results obtained in Experiment 76.

CONCLUSIONS.

This series of experiments has confirmed the earlier work carried out in this country in that they show the great superiority of early sowing of Douglas fir over spring sowing. In an exceptionally favourable year spring sowing may give satisfactory results, but in years of drought like 1933 and 1934 it leads to a very poor germination.

The method which has proved best is to stratify the seed in sand for 60–70 days beginning about the end of January. Consistently good results have been obtained with this treatment in three different years, and it has proved very successful in dry seasons. It is therefore recommended as a suitable method of treatment for the seed of Douglas fir.

Storage during stratification in flower-pots plunged in the soil, though from several points of view more convenient, does tend to encourage germination on account of the higher temperatures experienced towards the end of the period of treatment. This might easily lead to difficulties, as germination might begin in storage and make sowing necessary before suitable conditions could be obtained in the nursery. The method of storage in pits at a depth of about 18 inches is, therefore, on the whole to be recommended.

The experiments have shown that peat as a medium for stratification is not altogether satisfactory in spite of the American experience, and that stratification in sand for periods of more than 100 days is not to be recommended.

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Photograph 1. Effect of sand covering on seed-beds of birch. Kennington Nursery, 1931

Photograph 2. Effect of sand covering on seed-beds of alder. Kennington Nursery, 1931

PLATE III

Photograph 3. Lawson Cypress covered with soil
Kennington Nursery, 1931

Photograph 4. Lawson Cypress covered with sand
Kennington Nursery, 1931

PLATE IV

Photograph 5. Kennington Nursery. Experiment No. 46, 1932. The early sown plots stand out because of the weed growth. Beds covered with sand

Photograph 6. Kennington Nursery. Stratification in flower-pots at ground level. Sand and peat used as media. Pots protected from mice and birds

PLATE V

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MECHANICAL ANALYSIS OF SAND USED

(See p. 25)

A mechanical analysis of the soil from Kennington Nursery, kindly carried out by the Macaulay Institute for Soil Research, Craigiebucklen, Aberdeen, gave the following results: coarse sand 77 per cent., fine sand 6·7 per cent., soil 3·7 per cent., clay 12·5 per cent. The sand used for covering was 100 per cent. coarse sand.

HUMUS AND SOIL STRUCTURE IN THE FIELD

AN ABSTRACT FROM

The Study of the Soil in the Field[1]

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INTRODUCTION.

THE study of the soil profile as the manifestation of soil-forming processes is now fairly generally accepted, but little progress can be made in this country until a standard vocabulary and system for soil description is evolved. In this short note the writer has endeavoured to show the lines on which such a system could be built up, and to explain by the uses of two examples what a soil worker may observe, and the conclusions he might be expected to draw during the examination of an ordinary forest soil profile pit.

ORGANIC MATTER AND HUMUS.

The organic portion or the 'humus profile' of the soil is a manifestation of the biological reactions involved in the soil-forming processes. By a careful study of the visible evidence available from a study of the soil profile much information can be obtained with regard to the soil's life-history. Since the main portion of the humus of the soil profile is derived from the surface vegetation either by leaf fall or root decay, the nature of the leaf litter, grass mat, or vegetable debris should be examined and measured. The effect upon the soil profile produced by 10 cm. of oak litter is very different from that produced by 10 cm. of spruce litter, and such differences should be easily detectable by an observer. The approximate age of accumulations of leaf litter may sometimes be determined by carefully folding back, layer by layer, the annual leaf fall until the botanical structure of the leaves becomes vague and merged into the 'raw humus' layer of acid soils, or the 'mull' layer of the less acid and neutral soils. The problem of what is or is not 'humus' in soil nomenclature is too controversial to discuss in the field, where conclusions can only be drawn from observation of colour changes and the reaction with hydrogen peroxide. The phrase 'organic matter, nature and penetration of' in the profile questionnaire[2] will suffice for most field work. If the observer records, therefore, 'litter' as being that accumulation of loose unrotted vegetable material which retains its position by gravity alone he will not be far wrong from most of the generally accepted ideas. Lang uses the term 'Forna' for all that plant material which has not broken down into the darker and more compact 'vegetable mould' with the loss of its botanical structure.

[1] In preparation for the Press.

[2] See p. 53.

There are three main types of 'humus' which can readily be recognized in the field:

i. Raw humus or acid humus.
ii. Mull or neutral humus.
iii. 'Intimate humus' of the soil profile.

Such divisions rest primarily upon the differences in the nature of the vegetational parent material and the manner of its decomposition.

Raw humus is characterized by its excessive accumulation (slow decomposition), expandibility, and frequently by the presence of some structural remains of plants. A certain degree of lamination may sometimes be observed in the horizons of soils of the slightly podzolized type wherein the A_0 zone shows the 'clearly defined (3–5 cm.) boundary' to the truly pedological A_1 zone. Raw humus, though characterized also by an extremely low base content, does not show this in the field except in so far as granular structure is definitely absent, and unless the observer uses a pH outfit he is left with only what he can see from which to draw his conclusions. The writer cannot recall ever having observed raw humus with a pH value less acid than about 4·5.

Mull or neutral humus, on the other hand, though usually acid in reaction contains sufficient calcium to allow of a crumb or grain structure with a generally 'loose' or 'porous' constitution. The black organic material is usually more intimately mingled with the soil mineral particles to form indistinct and merging boundaries (5 cm.). The pH value of such mull layers varies from about pH 4·5 in the Brown Forest soil types up to about pH 7 or just over in the Rendzinas.

Hesselman, Romell, and Heiberg have evolved systems for the classification of Forest Soil Humus Types which are excellently summarized by Russell in *Soil Conditions and Plant Growth*, pp. 526 et seq.

Intimate Humus. This material is found truly incorporated in the soil mass and varies in colour from black, through the browns, to greys. Such material is responsible for the characteristics of the Chernozem, Black Cotton, and Brown Forest soil types. Intimate humus is not necessarily confined to the A horizon, but can be found dispersed and recoagulated in the B horizon of Podzols, Vleis, and certain other of the ground water soils. Highly decomposed intimate humus is frequently to be found in certain of the red and yellow tropical loams with black or grey surfaces. Certain other tropical soils show no visible humus whatever, neither do they effervesce violently with peroxide in the field, though they may contain up to 3 per cent. organic matter by carbon estimation in the laboratory. This intimate humus has more bearing upon the structure and constitution of soils in general than either of the preceding types, and particular care should be taken in its recognition and delimitation. Since it is so completely united into the soil mass pH measurements are not representative, so that the use of hydrogen peroxide and visible characteristics are the only criteria for its description.

The description of the incorporated soil organic matter commences at the

A_1 zone; its disposal around the soil particles, in interstices, or in the body of the structural elements should be noted. The degree and nature of cementation should also be determined by feel. Differentiation between cementation by humic or mineral material can usually be accomplished in the field either by means of acid, hydrogen peroxide, or a pocket lens. The extent to which humus is dispersed, mobilized, or transported down the profile is generally fairly easy to see. Calcareous soils tend to fix or immobilize humus near the surface, whereas leached and unsaturated soils tend to disperse and mobilize the humus down the profile into a secondary horizon. Sometimes basic ground waters are responsible for the very black stain observable in fen, vlei, and alkaline peat soils. The colouring and mobility of humus in saline and alkali soils depends much more upon their moisture content and permeability than upon the actual quantities of humus present.

In delimiting the penetration of humus down the profile, it is often convenient to pour a little hydrogen peroxide down the freshly cut face when effervescence ceases at the limit of intimate humus penetration. In this connexion, however, it is well to ensure that the peroxide is not acidic, or carbonates will interfere. This method may also prove erroneous in the field in the presence of concretionary (i.e. pedological) manganese, unless the precaution is taken to differentiate between the two. Concretionary manganese is usually only crushable between the thumb-nails and with a certain degree of force (elementary carbon is softer and usually structural). With peroxide, manganese usually reacts much more violently than humus, and if the reaction is carried out in the palm of the hand the burning sensation may be quite definite, and a little experience quickly teaches the technique. The streak on a piece of rough porcelain is also a conclusive test. Elementary carbon does not react with peroxide, and can rarely be mistaken on account of its position in the profile, its general appearance, and its easy crushability to form a black powder on the least pressure between the fingers.

STRUCTURE.

Soil structure is an exceedingly interesting phenomenon, and is capable of investigation under two different heads and in two distinct ways. It can be studied in the field by the simple exercise of the senses of touch and sight, and descriptions so obtained refer to the soil MACRO structure. What cannot be determined in the field because of the extremely small limits of the size of the aggregates, and their intricacy with the whole problem of soil life, ripeness, and fertility is termed MICRO structure. The ultimate effects of micro structure are frequently visible in the field by their effects upon the macro structure and soil profile generally, but the study of micro structure itself is still a problem for the agro-chemist or physicist in the laboratory.

Structure in the field, therefore, is the term defining the cemented aggregates or fragments into which the soil mass will crack, break, and be seen under conditions of the natural drying out of an exposed face or when a spadeful of the soil is tossed about a metre into the air and allowed to fall into fragments

by shock. These fragments are usually termed structural elements and are aggregates of the textural elements held together by colloids. No kind of structure is accidental, but is quite characteristic of the colloidal portion of the soil mass, and is formed as the result of the operation of certain definite factors. Every soil type possesses a structure specific to itself which under the influence of a new set of factors being brought into operation will tend to change this structure into some other equally characteristic type. Structure to some extent obeys the simple laws of crystal formation in that the breaking up of a large cubic aggregate results in the formation of smaller cubic aggregates. Structure is beginning to be recognized as one of the most important properties of the soil mass in that it influences the soil in almost all of its reactions, but especially with regard to aeration, moisture, heat, permeability, and water capacity. For example, a heavy clay soil can, by skilful cultivation, be made to attain a good granular structure and acquire many of the virtues of a good loam, due to the increased porosity, drainage, aeration, &c. The creation of one or the other of species of the 'Cubic Type' of structure to produce the 'Agronomic Structure' of Sokolovsky is the aim of all rational cultivation. The natural formation of structure may be due to various influences in the field which are briefly summarized below, while it may be artificially induced either in the field or in the laboratory by the treatment of the soil with various salt solutions.

(i) *Biotic influence*. The granulation produced by burrowing fauna, by worms, &c., or by man's interference.

(ii) *Periodic fluctuation* of moisture content either by alternate wetting and drying, or by rise and fall of water table to produce surface friction between the faces of expanding and contracting elements. This latter is peculiarly noticeable in gley horizons of soils of the heavy clay type.

(iii) *Destructive leaching* (i.e. by loss of exchangeable bases), by humus degradation, or by exposure and excessive oxidation.

(iv) *Root pressure*. Root development is frequently responsible for some changes in the shape and size of structural elements although in the writer's opinion it is more closely connected with the soil constitution than with structure alone. Some degree of lamination, however, may often be observed under forest where wind vibration causes stresses upon the lateral root systems of large shallow rooted trees.

(v) *True pressure* or the natural pressure of the soil itself within itself brought about by the expansion and contraction of colloids by variation in moisture content. Such phenomena may be responsible for the degradation of granular to a tighter clod structure, but may generally be assumed to be advantageous to granulation. Unnatural pressure, on the other hand, is immediately reflected in the loss of ripeness of soils which have suffered heavy mechanical cultivation. Whatever economic value in crop production may occur by the use of heavy machinery, there is undoubtedly a detrimental effect which is cumulative and which has not yet been sufficiently investigated to influence the recent craze for mechanization of small intensively utilized areas.

(vi) *Coagulation of colloids.* Coagulation may be produced either by precipitation by electrolytes, dehydration, freezing, or the reaction between oppositely charged colloids. The presence or absence of electrolytes in any particular zone or horizon is frequently manifested by the form the aggregates assume. Excessive accumulation of electrolytes or excessively degraded soils, on the other hand, are frequently described as being structureless or of a single grain structure.

Structural features belong to one or other of two main classes. The first occurs in what may be called (for want of a better term) the surface soil. This surface soil exhibits structures primarily under the influence of vegetation, fauna, and the direct effects of climate. The second class is usually insulated by the first from the direct effects of climate and fauna, but may still be influenced by vegetation, but is invariably influenced by the soil transpiration current,[1] and the percolation stream. It is probably due to the progressive diminution of humus down the profile and the effects of the basic soil transpiration current that the Brown Forest and similar organic soils are correlated with a progressive increase in size with depth of the structural elements.

Causes of Special Shapes.

The foregoing description of the factors which govern structure production are fairly well known, but little or nothing is known as to the causes for the specific shapes produced in the different soil types.

From a study of the measurements of the shrinkage of naturally moist structural elements the writer believes that there is some definite orientation of the ultimate soil particles in a soil mass which produces a form of cleavage plane along which the elements tend to separate. If fresh, well-shaped elements of the prism type or column-like type are allowed to dry out naturally it is found that there is a greater proportional shrinkage along the parallels of the major axis than along the parallels of either of the minor axes. Also, if and when columnar and column-like structures disintegrate they invariably fracture along the parallels of the horizontal axes to produce first jointed columns, then prisms, finally to become stable as cubes. The separation of the joints of the columns to form the cubes is explicable because the main expansion and contraction is along the vertical axis, so that it will cause an upward and downward motion of the element to produce friction against its lateral neighbours. Such spaces as exist between the elements will be closed up quicker by the expansion of the vertical faces by the percolating water than will the rest of the faces of the element, so that a strain will be exerted whereby the element is attempting to expand laterally but is locked by friction. The result is a 'lift' which cracks the element along the parallels of the minor or horizontal axes.

If a certain humus content and base status can be responsible for a certain orientation of ultimate particles it should be possible by changing this base status and colloidal binding power by leaching or regrading of the soil mass to change the shape and size of the structural elements. This is in fact the case

[1] Clarke, 'Brown Forest Soils of England', *Forestry*, vol. vii, No. 1, p. 43.

and can be observed both in the laboratory and in the field. The experiments of Sokolovsky wherein he changes a granular chernozem first into a tenacious and puddled sodium soil, and then back again to a granular calcium soil is a good example of laboratory technique. Field observations of the regradation of a salt marsh to a neutral grassland (i.e. a soda clay to a calcium clay) show that the process is not rapid but proceeds firstly by a degradation of column-like structure to jointed columnar, then to a somewhat spheroidal cube (rounded edges and corners), and finally to the true cube to produce a granular surface soil with a nutty subsoil. The stability of cube type is probably due to the fact that shrinkage takes place evenly along all parallels, and this must be brought about by the re-orientation of some of the particles to produce a neutralizing effect. The formation and alteration of the plate-like type of structure, being almost specific to certain saline soils of arid climates, probably obeys the same general laws of friction lift and consequent fracture, but the writer has had no opportunity to observe such examples.

Description of Aggregates.

There are two general methods employed in describing soil aggregates, and these must be discussed at some length. The most scientific and consequently the easier method is that evolved by the U.S.S.R. pedologists,[1] and confines the description of *structure* strictly to the *size* and *shape* of the elements, the *consistence* of the aggregates being described as a separate item. The American Soil Survey Association, on the other hand, uses some two dozen descriptive terms which may or may not embrace both the structure and the consistence of the aggregates.[2] Such a method, though useful, is liable to cause difficulties, since there appears to be no system of reasoning as to when consistence should be described separately and when it should be included in the structural name. For instance, 'Crumb', 'Granular', and 'Nutty', refer to aggregates of approximately the same size and shape, but 'Crumb' is 'porous', 'Granular' is of 'medium consistence', and 'Nutty' is 'compact, hard'.

The simplicity of the U.S.S.R. system is shown in Table I. There are three *types* of structure according to the *main shape* of the aggregates. *Types* are then further divided into nine *kinds* according to the nature of the *faces* and *edges* of the elements and into numerous *species* according to the *size* of the elements.

The A.S.S.A. system is outlined in Table II in such a manner as to give a rough idea of the Russian equivalent in the last column

Some Typical Structures to be found in Various Soils.

Brown Forest Soils. Upper Horizon. Has a Granular or, as the U.S.A. description above, Crumb Structure, the size and tenacity of which

[1] Zakharov, *Morphology of Soils*, Leningrad, 1927.

[2] At the present time the English Soil Survey Conference does not use any definite system for classification of structure and any terms are used which the man in the field thinks suitable for the case.

depends chiefly upon the dispersion or coagulation of the humus colloids by calcium. This horizon 'gradually merges' into the:

2nd Horizon, which is characterized by a lower humus binding power producing 'nutty' or small cloddy to small prismatic elements increas-

TABLE I. *Russian System of Classifying Soil Aggregates (Structure).*

Type.	*Kinds.*	*Species.*	*Size.*
(1) *Cube-like*:	A. Faces and edges indistinct and fragments irregular in shape	L. Blocks	10 cm.
		S. *Blocks*	10–5 ,,
		L. Clods	5–3 ,,
		Cloddy	3–1 ,,
	1. Block structure	S. Clods	1–0·5 ,,
	2. Clod structure	Pulverescent	0·5 ,,
Aggregates equally developed along 3 axes	B. Faces and edges *more clearly* marked and fragments *well defined*	Cuboid	20 mm.
		C. Nutty	20–10 ,,
		Nutty	10–7 ,,
		F. *Nutty*	7–5 ,,
	3. Nutty structure	C. Granular (beans)	5–3[1] ,,
		Granular	3–1 ,,
	4. *Granular structure*[1]	F. Granular (powder)	1–0·5 ,,
(2) *Prism-like*:	A. Faces and edges *indistinct.* Fragments *complex* and ill defined		Cross-section diam.
		L. Columns	5 cm.
		M. Columns	5–3 ,,
		S. Columns	3 ,,
	5. Column-like structure		
Aggregates developed dominantly along the vertical axis	B. Faces and edges *distinct.* Fragments well defined	L. Prisms	5 cm.
		Prismatic	5–3 ,,
		S. Prisms	3 ,,
	6. Prismatic structure (even faces—sharp edges)	Prismatic pencils (longer than 5 cm.)	1 ,,
	7. Columnar structure. Rounded tops—flat bottoms	L. Columns	5 cm.
		Columnar	5–3 ,,
		S. Columns	3 ,,
			Thickness.
(3) *Plate-like*: Aggregates developed along the two horizontal axes	8. Platy structure. Horizontal 'cleavage planes' developed	Schistose	5 mm.
		Platy	5–3 ,,
		Laminar	3–1 ,,
		Foliated	1 ,,
	9. Squamose structure. Horizontal faces small and partly curved	Vesicular	3 mm.
		C. Squamose	3–1 ,,
		F. Squamose	1 ,,

[1] According to Sokolovsky 'granular' structure possesses no sides, edges, or sharp angles and is stable under conditions of humidity but easily disintegrates under dry conditions.

ing in size with depth, which then changes with a 'clearly defined' horizon to:

The Gley which has a 'cuniform wedge' structure wherein the elements resemble triangular prisms resting on one long face with one edge upward.

TABLE II. *Outline of A.S.S.A. Classification of Structure.*

Name.	*Shape.*	*Size.*	*Consistence.*	*Russian 'Kind'*
Adobe	Cubic blocks	20–50 cm.	Not defined	
C. Cloddy	Irregular and angular	20 ,,		
F. Cloddy		8–20 ,,	*Hard*	Large Blocks to
C. Lumpy		6–10 ,,	*Medium*	Nutty
Lumpy		3–6 ,,	to	
F. Lumpy		2–3 ,,	*Hard*	
Nutty	Roughly rounded	0·5–4 ,,	*Compact hard*	
C. Granular		2 ,,	*Medium*	Nutty to
F. Granular		5 mm.		Granular
C. Crumb	Sub-angular and roughly	2 cm.	*Porous*	
F. Crumb	rounded	5 mm.		
Mealy		do.	*Soft*	
Buckshot	Roughly spherical	2–3 ,,	*Hard*	Pulverescent
Columnar	Vertical cleavage Horizontal cracks V axis = horiz. axis	*Not defined*	*Not defined*	Column-like
Prismatic Columns	Columns broken into regular sections	,, ,,	,, ,,	Prismatic and
Jointed Columns	Columns broken into sections where V axis = horiz. axis	,, ,,	,, ,,	Columnar
Platy	This plate parallel to surface	1–5 mm.	*Med. to hard*	Platy
Laminated		1 ,,	*Med. to soft*	
Amorphous	Structureless. Uniform arrangement too small to describe.			
Massive	No definite structure.			
Puddled	No definite structure. Massive structures degraded or defloculated.			
Single-grained	No definite arrangement (as particles in a coarse sand).			
Structureless	No definite arrangement.			
Crust	Surface effect. Horizon coheres in a crust distinct from lower horizon.			
Fluffy	Surface effect. Aggregates *loose*, light, and of fine texture.			
Floury	Surface effect. Aggregates *loose*, light, and of fine texture.			
Pulverent	Crumb or Grain produced from massive structure.			
Honeycomb	Network of regular sided elements separated by hair-like cracks.			
Reticulated	Network of regular sided elements separated by hair-like cracks.			

The faces and edges of each element are characterized by a blue burnish produced by lift friction.

Meadow Soils. Upper Horizon—consists of typical sod formation characterized by block structure and 'clearly defined' horizons into the

2nd Horizon of large columnar or large prismatic elements, in the faces of which may be found concretionary ochres and manganese. This 'gradually merges' to the Gley.

Rendzinas of the Red, Brown, and Black Calcareous Soils. Upper Horizon—characteristic granular structure, the size of elements depending entirely upon the calcium-humus content. This merges very gradually through the

A-C Horizon which is usually 'coarse granular' to 'small nutty' growing larger with depth. This horizon is a mean of the A and C.

Loamy Chernozem. Upper Horizon—granular to fine powdery.

Lower Horizons—nutty, increasing in size with depth to prismatic.

Heavy or Loam Podsols. Upper Horizon—small cloddy to pulverescent, dependent upon humus content which under influence of silicic acid becomes platy pulverescent (with no consistence).

Deeper Horizons (apart from actual pan formation) become platy and deeper to flat nutty.

Light or Sandy Podsols. Upper Horizons are faintly defined, foliated, or laminated which gradually merge into a structureless mass at depth.

Brown Alkali and Soils of Salt Marshes. Upper Layer squamose (scale-like, saucer-shaped) or distinctly foliated as it deepens to change suddenly to clearly defined columns with rounded tops in the alkali and to spheroidal cubes in the salines.

Cotton Soils. Upper Horizons—block or large clods which decrease in size with depth to give distinct foliation in and around the concretion accumulation zone.

In addition to their specific size and shape, structural elements also possess a certain power of resistance to further disintegration. This power of resistance is closely related to the proportion of organic and mineral colloid present and to their degree of hydration. Schoesing estimates that the binding power of the humus colloid compared to that of the mineral or clay colloid is in the proportion of about eleven to one. For this reason the A_2 zone of a sandy podzol when thrown into water becomes completely disintegrated, whereas the A_1 zone of the same soil will not completely disintegrate even when boiled with water, but if the colloids are first dispersed by an alkali, disintegration occurs immediately. This tenacity is closely related to the degree to which the soil colloids are hydrated. The degree of moisture present in the colloids of saline or alkali clay soils is responsible for their being exceedingly tough when wet but becoming workable at a specific moisture content and then again becoming unworkable as clod or dust soils on complete drying. Such characteristics are detectable in the field and are capable of a certain classification. The U.S.A. workers in the field deal with this characteristic under the heading of Soil Consistence, q.v.

Soil Constitution (of the U.S.S.R. Survey).

The U.S.S.R. pedologists use the term 'soil constitution' to describe the properties of the soil mass in regard to its 'porosity' and its 'compactness'.

Porosity is partly correlated with soil structure and is a property which may be *seen* in the examinations of the soil profile.

Compactness, on the other hand, is a property which may be *felt*, either during the digging operations in the soil mass or by the handling of the material in the freshly exposed soil pit.

Porosity is dependent upon the size, shape, and quantity of the air spaces as cavities or cracks in and around the soil aggregates of the whole soil mass and is classified under two heads.

(*a*) The nature of the cavities within the *whole* soil mass including the structure of the aggregates.

(*b*) The nature of the cavities *between* the structural aggregates.

(*a*)	I. Fine Porous	cavities	1	mm. diam.	as in degraded B.F.S. A Horizon.
	II. Porous	,,	1–3	,, ,,	Podsol and Loess.
	III. Spongy	,,	3–5	,, ,,	Podsols and B.F.S. (A_1) zone.
	IV. Cavernous	,,	5–10	,, ,,	Biotic Influence.
	V. Cellular	,,	10	,, ,,	Laterites.
(*b*)	1. Fine Fissured		3	,,	Usually vertical.
	2. Fissured		3–10	,,	Prismatic and Columnar soils.
	3. Clefts		10	,,	Alkali soils, heavy clay B.F.S. and meadow in dry weather.

Compactness is easily determined by the feel of the spade during digging operations.

(i) Very compact. A spade will not enter, a pick or bar is needed. (Some prismatic zones of the alkali soils and particularly the second layer of the salines.)

(ii) Compact. Soil fragments are very close together and a spade will only enter with difficulty. (B Horizon B.F.S. and Podsols.)

(iii) Loose. Separate soil particles. Spade enters easily and a sod readily falls to pieces. (Rendzinas and many of the Tropical loams.)

(iv) Crumbling. No cementation of the soil mass and little or no structure. Sandy soils and sometimes calcium saturated soils.

When taking notes of soil 'constitution' in the field it must be remembered that moisture, humus, new chemical deposits, and also biotic factors may greatly influence these characteristics, and any information obtainable is put in under the heading of Special Characteristics.

The foregoing Russian system of classification of constitution has much in common with the A.S.S.A. methods in the description of soil 'consistence' and 'porosity'.

Consistence is the term used to denote the degree of cohesion of the soil mass and its resistance to the breaking up of structural aggregates mainly under handling pressures.

Porosity is used in exactly the same sense as it is used by the U.S.S.R. (i.e. volume of air space). The following list of technical terms and their interpretation explains itself.

OUTLINE OF THE A.S.S.A. METHOD OF CLASSIFYING CONSISTENCE.

Name.	
Brittle	*Dry* soil breaks with clean, sharp fracture.
Cellular	Pore spaces of regular size throughout soil mass.

Cemented	Soil aggregates bound together by a cementing agent.
Cheesy	Characteristic of a *wet* soil. Elastic, bends without fracture.
Coherent	Compact. Very compacted.
Compact	Dense and firm without cementation.
Firm	Moderately hard, fragments can be broken between fingers.
Friable	Easily broken, and reduced to crumb structure.
Hard	Very difficult to crush between fingers only.
Impervious	Very resistant to water or root penetration.
Loose	Soil of small aggregates and maximum pore space.
Mellow	Porous mass, softer than friable, no tendency to pack.
Porous	Same as Russian.
Plastic	Readily moulded.
Soft	Readily crushed between fingers.
Sticky	Adhesive when wet, cohesive when dry.
Tenacious	Very like sticky but applies more to a cohesive character when wet.
Tight	Compact, impervious, and tenacious, usually plastic.
Tough	Bores easily but very difficult to break.

It may be seen from a comparison between the U.S.S.R. and the A.S.S.A. methods of description that they each have their points but the need for a standard vocabulary for the description of a soil in the field is urgently needed.

AN EXAMPLE OF A SOIL PROFILE DESCRIPTION

No. 27. INDEX No. 27.

1. *World Type* (Bodentypen)	Brown Forest Soil.
2. *Variety* (Bodenarten) (Series)	Loamy. Christmas Common Deep-Series.
3. *Catena or Region*	Dissected Eocene-Chalk Plateau.
4. *Locality or Map Ref.*	Chiltern Hills. England.
5. *Parent Material*	Reading Clay and Sands.
6. *Age of Site*	Mature.
7. *Mode of Formation*	Colluvial.
8. *Topography* Aspect, Slope, and Altitude	Ravine / South / Gentle / 200 ms. OD.
9. *Drainage* (Free or Impeded)	Mature. Impeded at depth.
10. *Climate, Rainfall* Temp., dry periods, &c.	Maritime-Continental. Rain 760 mm. even dist.
11. *Vegetation, Plant Association*	Beech. Oak. Ash Ass.
12. *Man's Interference and Management*	First Rotation, on old arable, limed last century.

PROFILE HORIZON DESCRIPTION

(Each horizon to be described in the following order.)

	A_0	A_1	B	C
13. *Horizon Name*				
14. *Depth and Clarity of Horizon* (A. Sharply, less than 3 cm. / B. Clearly more than 3 cm. / C. Merging more than 5 cm.)	3 in. clear	6 in. merge	9 in. merge	36 in.+
15. *Colour*	Dk. Br.	Dk. R. Br.	R. Br.	Y. R. Br.
16. Calc. or Non-Calc. (and nature of material concertionary or P.M.)	Non-Calc.	Non-Calc.	Non-Calc.	Non-Calc.
17. *Humus* (form of and penetration)	Neutral	mechanical and intimate	traces int.	nil
18. *Texture* (sand, loam, clay, &c.)	——	Loamy	Heavy loam	Heavy loam
19. *Structure* (shape of aggregates)	——	C. Gran.	F. Nutty	Cloddy
20. Consistence or Constitution (compactness, porosity, &c.)	Spongy	F. Porous	Compact	Compact

21. *Special Characteristics*, e.g.

Degree of moisture. pH. Chemical deposits. Root penetration and nature of. Fauna, effects of. Proportion of mineral skeleton, and nature of stones

A_0. Well-rotted litter / field-mice and worms/
A_1. Damp / grd. veg. roots / mice and worms / many flints
B. Drier / tree roots good / worms / many flints towards bottom of horizon dendrites of manganese on flints and structure faces.
C. Normal weathering of P.M. with little or no evidence of gley

A NOTE ON THE INFLUENCE OF SEED WEIGHT ON PLANT WEIGHT

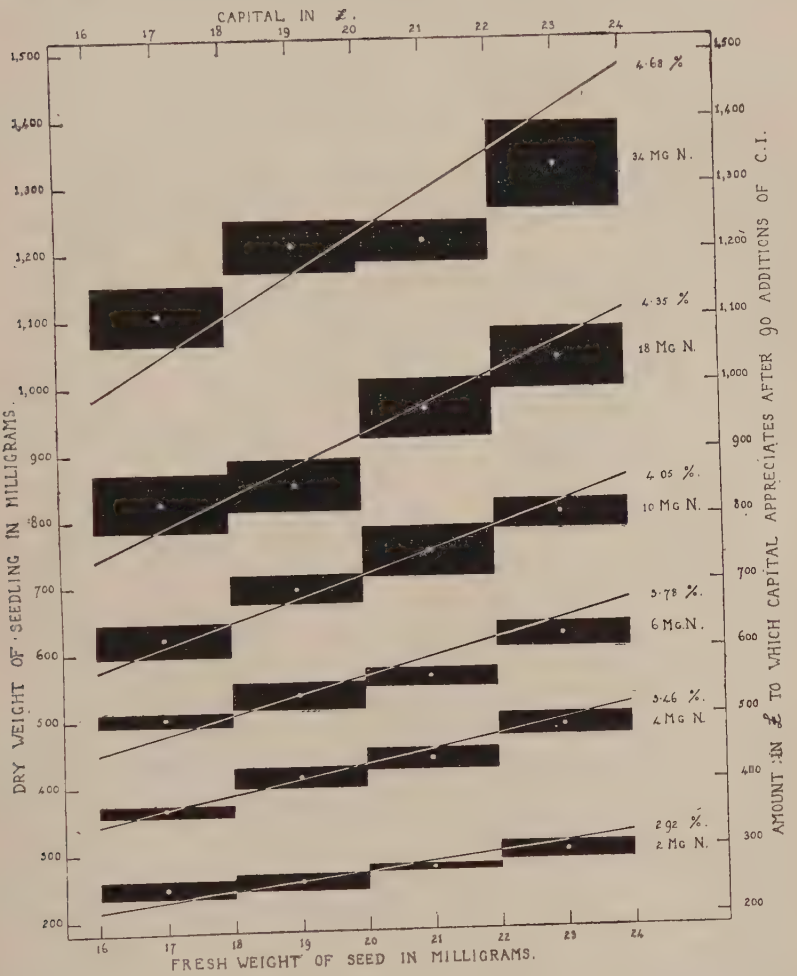
BY R. N. ALDRICH-BLAKE

IN a study of the influence of nitrogen on the development of Corsican pine seedlings in sand culture the writer (1) made some observations on the relationship between the fresh weight of the seed used and the dry weight of the resulting seedlings. These were grown with an adequate supply of all essential nutrients except nitrogen, which was supplied in the form of ammonium nitrate in quantities which provided 0, 2, 4, 8, 16, and 32 milligrams of nitrogen per plant in the six distinct treatments. The nitrogen content of a seed of the average weight used was 1 milligram; and that of seedlings to which no ammonium nitrate was supplied was $1{\cdot}94 \pm 0{\cdot}10$ milligrams, indicating that each seedling could obtain about 1 milligram of nitrogen from extraneous sources. Thus the total amounts of nitrogen available per seedling were 2, 4, 6, 10, 18, and 34 milligrams respectively. There were six replications of each of the six treatments, each replication consisting of a pot of 52 seedlings, 13 grown from seed of each of the following fresh weight classes: 16 to 18, 18 to 20, 20 to 22, and 22 to 24 milligrams, with equal numbers of seeds 16 to 17, and 17 to 18 milligrams in the 16 to 18 milligram class, and so on in the other three classes. In each pot the mean seedling weight for each seed weight class was determined by weighing the whole batch and dividing by the number of seedlings; so that the standard errors of the mean seedling weights refer to variance due to replication, not to individual variance.

The results were briefly discussed with reference to Blackman's (2) analogy between the increase in dry weight of a plant and the appreciation of a money loan at compound interest. On this analogy the seed weight corresponds to the amount of capital invested, the rate of increase in dry weight, more rapid the greater the supply of nitrogen, to the rate of interest earned, and the dry weight of the plant to the sum eventually accrued. Now the relationship between the amount of a money loan and the sum to which it appreciates at compound interest is linear; and the straight line expressing this relationship ascends more steeply the higher the rate of interest. The relationship between seed weight and resulting plant weight should therefore be linear, and an increase of seed weight should have a greater effect on plant weight the greater the supply of nitrogen. If the analogy be correct the correspondence between the two phenomena should be demonstrable by graphical means.

A graph expressing this dual relationship was not published in 1930, since there was then a reasonable prospect of obtaining more satisfactory results from an experiment designed primarily for the purpose. The available data were unsatisfactory in a variety of ways. In the first place the dry weight of the seedling should have been related to the dry weight of the seed minus the seed-coat, or perhaps preferably to the lowest dry weight attained by the seed

minus seed-coat during germination; for this weight corresponds most closely to the original capital of a money loan. Secondly, each seedling should have been weighed separately, since the standard error of the mean seedling weight should refer to individual variance. In the third place, seeds of a wider range of weight should have been used. Only those weighing between 16 and 24


CAPITAL IN £.
16 17 18 19 20 21 22 23 24
1,500 1,400 1,300 1,200 1,100 1,000 900 800 700 600 500 400 300 200
DRY WEIGHT OF SEEDLING IN MILLIGRAMS.
AMOUNT IN £ TO WHICH CAPITAL APPRECIATES AFTER 90 ADDITIONS OF C.I.
4·68 %
34 MG N.
4·35 %
18 MG N.
4·05 %.
10 MG N.
3·78 %.
6 MG.N.
3·46 %.
4 MG N.
2·92 %.
2 MG N.
FRESH WEIGHT OF SEED IN MILLIGRAMS.

milligrams were sown, while seeds obtained from a single tree ranged from 6 to 29 milligrams in fresh weight. Finally, the seedlings should have been spaced slightly farther apart. Those grown with the heaviest dose of nitrogen were somewhat crowded; and the check on growth, due to the shading of the lower needles, must have been relatively most severe in the case of the larger plants grown from the heavier seeds.

There are now no prospects of my securing improved results, and it seems desirable that a graph should be published, despite the above criticisms of the

data used therein, for it is essential that the effect of seed weight be eliminated in future accurate studies of the influence of other factors on plant yield; and it appears that the short discussion of the results in 1930 failed fully to explain the difficulties of so doing.

In the graph now shown the white dots in the centres of the black rectangles represent mean seedling weights graphed against average seed weights. The length of these rectangles represents the range of seed weight used, their height the standard error of the mean seedling weight. Figures on the right of each set of four rectangles show the amount of nitrogen available to each seedling. The lines, drawn in white wherever they cut the rectangles, represent the sum in £ to which capital sums of £16 to £24—corresponding to the seed weight in milligrams—would appreciate at compound interest after 90 years, with annual addition of interest to capital, at the rates of interest shown on the right.

It is not claimed that the rates of interest here shown indicate the rates of interest at which the plants whose representative rectangles are cut thereby have grown. If the dry weight of a growing coniferous seedling be graphed against time an S-shaped curve is obtained. During germination the dry weight decreases. From the time of the appearance of the cotyledons above ground until the latter part of the season the curve ascends, and follows a compound interest formula. In early autumn it gradually flattens out, owing to decreasing temperature and sunlight, and owing to the storage as reserves of an increasing proportion of the primary products of photosynthesis. Now we cannot at present determine how soon after absorption a molecule of carbon dioxide becomes incorporated into actively earning root or shoot tissues. Much of the material absorbed during a day may be fashioned into new tissues that same day. Some of it certainly is not; for the amount of starch temporarily stored in leaves increases during the day. But the almost complete nocturnal depletion of these reserves shows that in general practically all the raw materials absorbed during a day are at least mobilized in soluble form for the production of new tissues by the following morning.

The seedlings from which our data were obtained were sown in mid-May and harvested during October. They received their first dose of ammonium nitrate on 7 June, and from about the following day must have increased in weight at distinct rates dependent on the amount of nitrogen received. A period of 90 days from 8 June extends to 6 September, the approximate date at which the dry weight increment of a coniferous seedling slows down. Thus the rates of interest shown in the graph may approximate roughly to the diurnal rates of increase of the seedlings. At present we cannot say how far this diurnal rate corresponds to the true percentage increment, owing to the above-mentioned difficulty of determining the exact degree of continuity of addition of 'interest' to 'capital'.

It may even be that these approximate diurnal rates of increase are merely average rates for the whole period. For the growth-rates of seedlings receiving little nitrogen may have slowed down earlier than those of seedlings receiving

much. But the test of the truth of the analogy by this graph does not depend on our ability to assess even the diurnal rate of increase thereby. It depends on our ability to draw through the centre of each set of four rectangles straight lines representing the amounts to which capital sums, corresponding to the seed weights, appreciate at compound interest. The rate of interest may be fixed, and the number of additions of interest adjusted so that the figures are suitable. Alternatively the number of additions of interest may be fixed, and the rates of interest chosen so that the lines pass through the rectangles. In our case 90 additions of compound interest have been made, because the resultant percentage rates of increase may approximate to the diurnal rates of increase of the plants.

Inspection of the graph shows that the 6 lines cut every one of the 24 rectangles, and pass through 15 of them in the centre of their length. The weights of the seedlings receiving 34 milligrams of nitrogen do not increase sufficiently steeply with increase in seed weight. This lack of agreement may be due to the overcrowding mentioned above. Thus in the results of this work the analogy receives considerable support; and future research should be directed towards a more accurate test thereof. At all events the data are adequate to show that seed weight has a greater effect on plant weight the greater the supply of nitrogen.

In this number of *Forestry* the writer is reviewing a paper by Mitchell (3), who, unable to procure sufficient pine seed of one weight class for his experiment, used seed of one weight class to grow seedlings supplied with one quantity of nitrogen, seed of another weight class to grow seedlings supplied with another quantity of nitrogen. He corrected the determined plant weights to those which would have been obtained from seeds of a single weight class by the introduction of correction factors. These factors were derived from a linear graph expressing the relation between seed weight and the resultant weight of seedlings grown in sand devoid of all nutrients. Now the slope of such a graph must certainly have been less steep than that of a graph expressing the relation between seed weight and the weight of seedlings grown with a considerable supply of nutrients. The employment of such correction factors cannot yield accurate results. In cases where sufficient seed of one weight class is not available it is preferable that seed of several weight classes should be distributed equally to each of the several treatments. The determination of reliable correction factors would involve an experiment as arduous as the main experiment for which such factors were designed.

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MALE TREES OF *SALIX ALBA* VAR. *CAERULEA*

BY J. BURTT DAVY

(Imperial Forestry Institute, Oxford)

THE late Professor Augustine Henry, in his account of *Salix alba* var. *caerulea* Smith (*The Trees of Great Britain and Ireland*, vol. vii, p. 1764, 1913), states that 'apparently no staminate tree of *S. caerulea* exists; and Smith knew it only as a female tree'. Mr. W. J. Bean (*Trees and Shrubs Hardy in the British Isles*, vol. ii, p. 479, ed. 2, 1919) says that 'only the female tree is known'; in this he was probably following Henry, as he did not make the statement in his original account of the Cricket-bat Willow (*Kew Bulletin*, 1907, pp. 311–16).

In the course of investigations on the Cricket-bat Willow and its allies, which Mr. W. R. Day and the present writer have been conducting during the last two years, we have found growers and buyers generally of the opinion that there is no such thing as a male *caerulea*; any male tree of the *Salix alba* group is usually referred to as *Salix viridis*, irrespective of varietal distinctions in leaf indumentum, dotting, or margin, in shape and length of bracteoles, or in the ovary or capsule. Probably the idea that no male tree can be a true *caerulea* has been developed from the statements of Henry and of Bean quoted above. We have been informed that buyers of first-class bat timber reject all trees known by them to be males, though we have no other evidence that inferior quality of willow wood is definitely linked with sex.[1]

In East Anglia Mr. Day and I have met with several staminate trees of *Salix alba* var. *caerulea* Smith. They agree with it in having the same leaf-shape and hairiness, the same type of bracteole, and in that upright habit of branching which produces the somewhat conical crown so characteristic of this variety.

At Roos Hall, near Beccles, we found a male tree (specimen No. 26516) which had its branches less spreading and less drooping than in the staminate form of *S. alba* L. usually met with, while the bark was precisely like that of near-by *caeruleas*. Two specimens growing side by side at Lavenham, Suffolk, were indistinguishable as to branching and bark, but one was male and the other was typical female *caerulea*. These are shown in Plate VI, fig. 1; the tree on the left-hand side is a male *S. alba* var. *caerulea*; that on the right is a female.

The tree with wide-branching and somewhat drooping habit, shown in Plate VI, fig. 2, is a male of another variety.

In his original description of *Salix alba* var. *caerulea*, Sir J. E. Smith mentioned only the pistillate tree, though he did not state that the other sex was

[1] A willow-buyer near Braintree, in Essex, informed us that he knew of a tree which he could only distinguish from true *caerulea* when it was in flower, as it then had yellow catkins. This indicates that the tree was a male.

PLATE VI

FIG. 1. Male and female trees of *Salix alba* var. *caerulea* at Lavenham, Suffolk. 30 April 1933

FIG. 2. *S. alba* ♂. Lavenham, Suffolk. 30 April 1933

Male *Salix alba* var. *caerulea* Smith. Photograph of a plate in Forbes's *Salictum Woburnense*

1 = anther; 2 = filament; 3 = scale; 4 = bracteole

PLATE VII

unknown. In 1829 Forbes, in his *Salictum Woburnense*, published a figure of a staminate tree as *S. alba* var. *caerulea*; this is here reproduced from a photograph (Plate VII). This book was issued under the authority of, and with an introduction by, the Duke of Bedford. Sir James Smith was on intimate terms with the Duke, by whom his attention was first called to a new species of willow to which he gave the name *Salix russelliana* Smith, in honour of the Duke. This being the case, it is almost certain that Sir James was familiar with the various species of willow being grown in the Salicetum at Woburn; and as Forbes, in the *Salictum Woburnense*, cited Smith's descriptions, it is most unlikely that the plates would have been published without having been first submitted to Smith.

It is not improbable that male *caeruleas* have been cut and used for bat-making, for they appear to be indistinguishable from female trees, except when bearing catkins. Male trees of *S. alba* and its hybrids, however, are in many cases at least distinguishable even when not in flower by the drooping tendency of the branchlets.

Since the above was written, Miss Ida M. Roper, F.L.S., has informed me that she has in her herbarium a sheet of staminate *Salix alba* var. *caerulea* Smith, collected on Kenn Moor, N. Somerset, 22 May 1915. Sheets of this gathering were sent to the Watson Botanical Exchange Club, and commented on by the Rev. E. F. Linton, who wrote 'rightly named' (see *Report*, 1915–16, p. 554).

BUTT ROT OF CONIFERS

BY W. R. DAY AND T. R. PEACE

IN all the continental countries where conifers have been used on a large scale for afforestation or reafforestation butt rot has proved to be a serious source of loss. A brief survey of the literature on the subject yields the information that only a limited number of fungi are involved and that some of these are of much commoner occurrence than the others, that certain species of trees, at any rate under certain conditions, are much more liable to this form of attack than others, and that certain sites definitely favour butt rot. But the evidence on all these points, and particularly on the last one, is very contradictory. In this country, owing to our comparatively limited experience with conifers, we have practically no data to go on; in view of the large area of conifers now being planted, such information is obviously of importance. It may well prove that the origin of the trouble can only be elucidated by an exhaustive investigation of the roots of healthy and rotted conifers, and of their relation to the soil on which they are growing; but such an investigation could obviously only be carried out on a limited number of sites, and before it is undertaken we ought to know much more about the general importance and distribution of butt rot and of the fungi associated with it.

With this end in view, specimens have been sent in, by the kindness of the Forestry Commission, from plantations where, on felling or thinning, butt rot was found. A series of visits to plantations where felling or thinning is in progress has also been begun, and full data about such sites, whether butt rot was present or not, is being recorded. So far, we are in a position to state that *Fomes annosus* is the fungus most commonly found in association with this type of damage; but *Stereum sanguinolentum*, *Polyporus schweinitizii*, *Pholiota squarrosa*, and *Armillaria mellea* have also been found, and an investigation of a larger number of specimens will probably add to this list. Much more investigation will be required before it is possible to make any statement on the relative susceptibility of different tree species, or on the effect of site and soil on the disease. It is obvious that it can occur on a great variety of soil types, and some of the sites on which it has been found to have assumed serious proportions would appear on a superficial examination to be quite suitable for healthy tree growth. It is probable, however, that when data for a larger number of sites have been collected, certain soils will stand out as favourable or the reverse. It has been stated on the Continent that the previous crop affects the incidence of butt rot, old agricultural land being particularly mentioned as a cause of trouble in the conifer crop planted on it. In this country larch following larch is said to lead to butt rot in the second crop. It is unfortunate that the haphazard nature of so much of our pre-war forestry in this country has led to a lack of records, and for most of the older coniferous plantations the previous crop is not known. Information on this

point is, therefore, hard to come by. So far, a great proportion of the material sent in and collected has been from European larch, and a rather smaller proportion from Norway spruce. This no doubt is in some measure merely a reflection of the relative commonness of these two species, but it may also be some indication of their susceptibility to butt rot. It is almost certain that Scots pine is less susceptible than either of them. Material from other species is badly needed, not only in order to get information on their relative susceptibility, but also to find whether the same fungi are concerned.

We should be grateful to any one who, finding butt rot when felling or thinning coniferous plantations of twenty years of age or over, would send typical specimens to us at the Imperial Forestry Institute, Oxford. Specimens should consist of the bottom 6 inches of the trunk; where this would be unduly large it could be halved or quartered and one piece sent. In view of the fact that so many of the state conifer plantings are on land not previously under forest, specimens from conifer woods on sites of this type would be of particular interest, as giving some indication of the importance that butt rot is likely to assume in the future. Particulars of sites where, on felling, butt rot was found to be entirely absent would also be of interest. If any one who is able to send material, or particulars, of rot areas would be so good as to notify us, we will let them have short forms which indicate the data on age, soil, &c., which we are trying to collect for each site. It is hoped that an examination of the data collected in this way, in the course of personal visits, and from the Forestry Commission sample plots, will put us in a position in two or three years' time to say far more accurately than we can at present what the status of coniferous butt rot in Great Britain is, and will give us a sufficient idea of the possible causes underlying its incidence to decide what lines of more detailed research can profitably be followed.

FURTHER TESTS ON THE EFFECT OF PROGRESSIVE DECAY BY *TRAMETES SERIALIS* FR. ON THE MECHANICAL STRENGTH OF THE WOOD OF SITKA SPRUCE

BY F. H. ARMSTRONG

(Forest Products Research Laboratory)

THE loss in strength of timber resulting from fungal decay has been the subject of a number of scattered investigations. It is, however, only recently that an attempt has been made to correlate the progressive alterations that take place in the mechanical strength of wood with the physical and chemical changes when exposed to fungal attack under controlled conditions. Experimental methods evolved at the Forest Products Research Laboratory have shown that it is possible to carry out accurate mechanical tests on very small test-pieces infected with fungus and to correlate the loss in mechanical strength with the progress of decay. These methods have been recorded fully in a previous publication (1), which summarizes earlier work and deals with the effect of progressive decay by *Trametes serialis* Fr. on the mechanical strength of the wood of Sitka spruce in resisting bending under a load applied without shock.

The present investigation was initiated in order to examine the effect of progressive decay by *Trametes serialis* Fr. on the crushing strength of the wood of Sitka spruce with a view to correlation with the results obtained in the experiment mentioned above.

MATERIAL.

A good quality Sitka spruce baulk, about 12 inches by 5 inches in cross-section, was obtained for the investigation. A length of 66 inches was cut from this baulk and, in order to avoid possible unequal moisture conditions in the fibres on the outside of the baulk, it was planed on all four sides to a depth of $\frac{1}{2}$ inch. The conversion was carried out in a similar manner to that in the previous investigation (1), the 66-inch length referred to above supplying test-pieces for inoculation and for the controls. The specimens which were used for the compression tests were carefully selected for straightness and evenness of grain, and any test-piece showing resin pockets was rejected.

The average moisture content of the timber at conversion was 12·6 per cent., based on the oven-dry weight.

EXPERIMENTAL METHODS.

(*a*) *Sterilization and Inoculation.* All the test-pieces were sterilized by steaming in flasks at 100° C. for 1 hour on each of three consecutive days. The specimens allocated for exposure to the fungus were inoculated as in the previous experiment. The fungus used was, as before, *Trametes serialis* Fr.

(*b*) *Mechanical and Physical Tests.* The mechanical test applied was com-

pression parallel to grain, and the maximum crushing strength of the timber was recorded. Bobbin-shaped test-pieces as shown in Plate VIII were used. Moisture content and specific gravity determinations were made on each specimen.

The control specimens were tested in one batch immediately after sterilization. The first inoculated test-pieces were removed from the culture flasks for test at the end of 3 days. Subsequently further specimens were removed at intervals of 3 days up to the first 48 days of incubation, and afterwards at intervals of 6 days up to and including the 66th day of incubation. As in the previous experiment, the loss in dry weight of wood substance was determined for each test-piece.

(*c*) *Microscopic Examination.* One specimen of each group was examined microscopically after test, and the amount of mycelium noted.

RESULTS AND DISCUSSIONS.

The results of the tests, which are shown diagrammatically in Fig. 1, suggest that the crushing strength of the timber was immediately affected by the

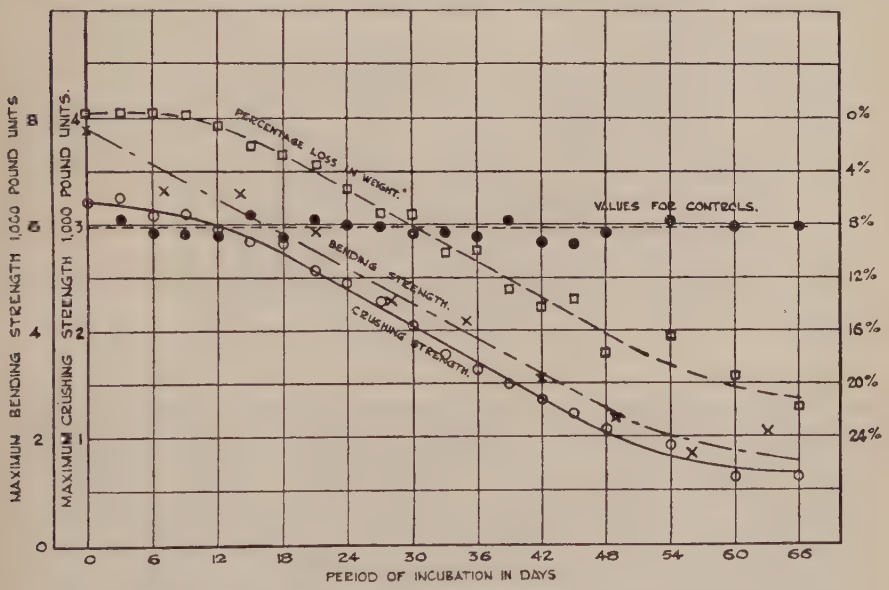


FIG. 1. Curves showing loss in crushing strength, loss in bending strength, and loss in dry weight related to exposure to fungal attack.

fungal attack. The rate at which the strength was reduced was slight in the early stages of exposure and increased until about the 21st day. During the next 24 days the strength depreciated at an approximately uniform rate of about 2 per cent. per day. The rate then gradually diminished until the experiment was concluded on the 66th day, when the loss in strength was of the order of 80 per cent.

Presumably the accelerated depreciation in the early stages corresponds to

the spread of the fungus through the test-piece. Microscopic examination revealed that after 21 days' exposure the fungus was plentiful throughout.

Considering now the loss in dry weight resulting from exposure to the fungus, it will be observed that the curve in Fig. 1 representing this quantity closely shadows the curve showing loss in strength, thus indicating a close correlation between strength and decay, as evidenced by loss in weight, but a slight loss in strength was evident before the loss in weight was measurable.

The effect of the fungal attack on the type of failure is shown in Plate VIII, which illustrates the failures in two groups of specimens: unexposed, and after 60 days' exposure, respectively. The advance of fungal attack is marked by a very much more brittle and irregular type of fracture.

COMPARISON WITH PREVIOUS TESTS.

It is of interest to compare these results with those previously obtained employing the static bending test. For this purpose a curve illustrating these latter results is included in Fig. 1. It will be observed that the curves differ only where they relate to the early stages of exposure, during which the bending strength was reduced at a very much higher rate than the crushing strength. This is explainable by the fact that, in bending, the maximum tensile and compressive stresses occur in the outside fibres, which are attacked in the early stages of exposure, whereas in the compression test the stress is distributed uniformly over the section under test. Initially, therefore, the loss in bending strength is disproportionate. Taking these factors into consideration, the results of the tests may be considered to be in close agreement.

SUMMARY.

1. Compression parallel to grain tests were made on bobbin-shaped test-pieces of Sitka spruce attacked by *Trametes serialis* Fr.

2. The effect of progressive decay on the crushing strength has been examined and leads to the following conclusions:

(*a*) A close relationship exists between the reduction in compressive strength and the progress of the decay as evidenced by the loss in dry weight.

(*b*) The advance of fungal attack is indicated by an increase in brittleness and irregularity of the type of fracture.

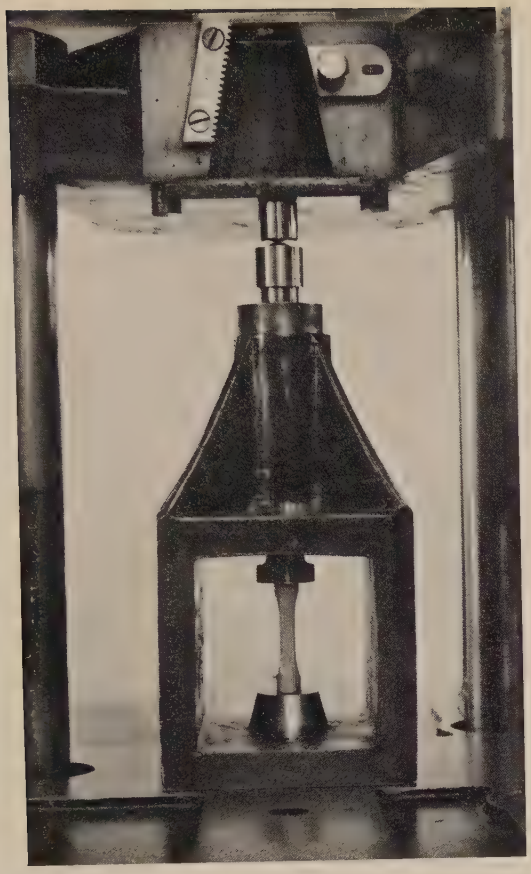
3. The conclusions reached in a previous investigation employing static bending tests were confirmed.

ACKNOWLEDGEMENTS.

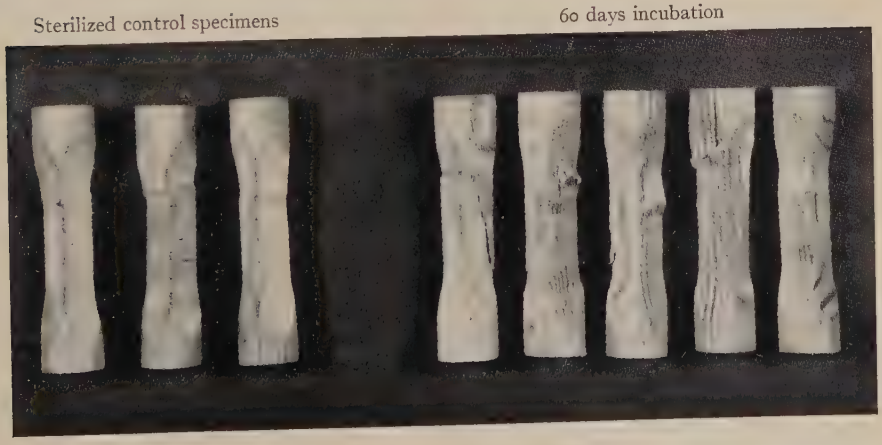
The author expresses his indebtedness to Mr. W. A. Robertson, F.R.G.S., Director of Forest Products Research, for permission to publish these results, to Mr. C. J. Chaplin, M.Sc., M.I.Mech.E., under whose direction the investigation was carried out, and to Mr. K. St. G. Cartwright, M.A., for carrying out the mycological work.

LITERATURE REFERENCE

(1) *Forest Products Research Bulletin*, No. 11, 1931.



SPECIMEN UNDER TEST



TYPES OF FAILURE

Types of fracture of bobbin-shaped compression specimens after 60 days exposure

PLATE VIII

SOCIETY'S AND OTHER NEWS

NOMINATION OF OFFICE-BEARERS AND COUNCILLORS

MEMBERS are reminded that nominations for election of office-bearers and councillors at the Annual General Meeting in 1936 must be in the Secretary's hands by 31 October next. There is no special form of nomination, the only requirement being that the nomination must be in writing and be signed by TWO Professional Members (i.e. Fellows or Associates).

Nominations are required for the following:

Office-bearers, to hold office for one year: President, Vice-President, Editor of Journal, Business Editor, Secretary and Treasurer, and Auditor.

Councillors, to hold office for two years: THREE. A list of those now in office will be found at the beginning of this number. The retiring office-bearers and Councillors are all eligible for re-election.

EMPIRE FORESTRY DINNER

IT is proposed to hold a dinner in London on 30 July next for those connected with forestry in this country and the Empire. Lord Stonehaven, Chairman of the Empire Forestry Association, will take the Chair. It is hoped that delegates to the Fourth Empire Forestry Conference passing through London on their way to South Africa will be able to attend. The cost of the dinner will not exceed ten shillings (exclusive of wines).

Any members of our Society wishing to attend should send their names to our Secretary as soon as possible.

SOCIETY OF AMERICAN FORESTERS

A REPRESENTATIVE of the Society of Foresters of Great Britain, Mr. T. W. Summers, was present at the last Annual Meeting of the Society of American Foresters, and gives a short account of the proceedings:

The Society of American Foresters held its annual meeting in Washington, D.C., on 28, 29, and 30 January 1935. At the opening session Mr. F. A. Silcox, head of the United States Forest Service, spoke on the need for immediate stoppage of destructive practices and for more public control of private land. The President of the Society, Professor H. H. Chapman, mentioned the function of the Society in the present extensive forestry programme. Discussion in the afternoon centred on the Lumber Code and the methods to enforce the conservation provisions. Education was the evening subject, and the opinion gathered from many graduates was that the courses did not lay enough stress on English and economics and that the entrance should be harder.

Society affairs occupied most of Tuesday. In the afternoon reports from the Society's committees were read. The Subsistence Homesteads were mentioned as a necessity for success of sustained yield management, which requires rangers to live in the forest. Co-operation with other professions was suggested as being beneficial to forestry.

At the annual dinner, the Chairman read out the message[1] from Sir Alexander Rodger to the President of the American Society, and this was received with hearty applause.

[1] Printed below.

Wednesday morning was devoted to state forestry problems. Rivalry between adjoining states leads to greater efficiency all round. There was need for a federal grant to aid states in purchasing land. The question of fire control in the south received attention from the last five papers. Land protected showed 23 per cent. less area burnt than the unprotected land. Experiments which controlled firing were showing favourable results. Grazing is a major problem and must be limited.

T. W. Summers.

Forestry Commission,
9 Savile Row,
London, W.1.
4th January 1935.

From: Sir Alexander Rodger, President, Society of Foresters of Great Britain.
To: The President, Society of American Foresters.

Sir,

I have much pleasure in introducing Mr. T. W. Summers, a member of our Society, who will represent us at your Annual Conference. It was a disappointment that I was unable to come over myself and take part in your deliberations. It would have been a splendid opportunity to draw closer together the bonds which bind the foresters of America and Great Britain, and I should have greatly valued the opportunity of getting into touch with your great scientific men and learning something from them of the difficult and important problems confronting them. Forestry in America has always had a very special interest for us in Great Britain and India, and I am quite sure we could learn a great deal from the experience of American foresters in their vast and splendid forests. I hope that in future our relations will continue to become closer.

Sir John Sutherland, a past President of our Society, who has just had the honour of Knighthood conferred upon him, is an Hon. Member of your Society and values his membership very highly. He joins with me and with the other members of our Council in sending to your Society a most cordial greeting through Mr. Summers.

I am, Sir,
Yours very truly,
Alexander Rodger.

COLONIAL FOREST RESOURCES DEVELOPMENT DEPARTMENT

The Secretary of State for the Colonies has set up an organization under the Colonial Office for the development of colonial forest resources. By consent of the Department of Scientific and Industrial Research two of their technical officers have been transferred to the new organization, namely Major F. M. Oliphant, lately Assistant Director of the Forest Products Research Laboratory, Princes Risborough, and Major J. R. Cosgrove, D.S.O., M.C., M.E.I.C., lately in charge of the Section of Utilization at the Laboratory. Major Oliphant, as Forest Economist, will deal mainly with the organization of production and will spend much of his time in the Dependencies concerned, while Major Cosgrove, as Market Development Officer, will be engaged in market promotion work, with reference to the United Kingdom market and other markets, both British and foreign. The organization will be chiefly concerned with timber development, but will also interest itself in other forest products, such as wood pulp, fibres, gums and resins, and the like. In both directions it will co-operate with the Imperial Institute. It will also work, of course, in close co-operation with the Forest Products Research

Laboratory. The Laboratory, as a research institution, will henceforward confine itself to questions involving scientific investigation and tests, while the new organization will take over the market promotion work, including commercial service trials, which the laboratory formerly carried out under temporary arrangements on behalf of the Empire Marketing Board. The organization will for the present be quartered at the Imperial Institute. Inquiries should be addressed to the Colonial Forest Resources Development Department, Imperial Institute, London, S.W.7.

Colonial Office,
2nd April, 1935.

DR. LEONARD COCKAYNE, C.M.G.

Those members of the Society of Foresters who were out in New Zealand with the last Empire Forestry Conference and who came into contact with Dr. Leonard Cockayne, will learn with regret of his death in Ngaio, Wellington, on 8 July 1934. As one of the early ecological botanists, and chiefly as one of the few who have attempted to relate the ecology of New Zealand forests in its widest sense to the possibilities of silvicultural management, Dr. Cockayne's name must remain as a sign-post to foresters in Great Britain and elsewhere who are endeavouring to 'get back to Nature' in the rebuilding of the forests of their respective countries. Of particular interest, perhaps, to members of the Society of British Foresters, but of immense value to foresters throughout the world, is Dr. Cockayne's study of the genus *Nothofagus* with its resultant findings of widespread hybridism in the genus—a fact not only of botanical but of silvicultural importance in the future management of New Zealand beech forests.

As Honorary Botanist to the New Zealand State Forest Service, and as an Hon. Member of the New Zealand Institute of Foresters, Dr. Cockayne's influence was spread amongst the small working body of foresters in the Dominion; and his personal enthusiasm and directness was a definite fillip to their forestry reasoning and keenness. He could not suffer gladly those whom he considered fools, nor lukewarm helpers in his work, but to those who passed his standard of keenness, equally in disagreement as in agreement with his own views, and to younger workers, he never spared himself in guidance and encouragement.

Dr. Cockayne was a successful example of the old-style system of education—of a thorough grounding in the 3 R's, together with a classical leaven acquired at an early age ('I was reading Greek at 6 years') which produced the man of all-round thought coupled with the ability to work out his own branch on wide, reasoned lines—his scathing indictment of our present spoonfed generation was a treat which had to be heard to be appreciated.

To New Zealand foresters his passing removes a stimulating, kindly friend whose presence on a field trip contributed much to the wit and inspiration of the party.

M. Sutherland.

REVIEWS

Recent Research on Fungi causing Blue Stain and their Control

By W. P. K. Findlay

RESEARCH on the fungi responsible for blue stain and on means for their control is now being carried on actively in many different countries, and the widely scattered literature on the subject is rapidly growing. From Japan comes a paper by Nisikado and Yamauti (3) which is the second of a series dealing with the sap-stain fungi of Japan, and describes in detail the morphological and cultural characteristics of *Ceratostomella pini* Münch, which they state to be responsible for most of the blue-stained wood commonly found in almost all parts of Japan. It attacks mainly two species of pine—*Pinus densiflora* and *P. Thunbergii*—frequently growing in the wood of standing trees weakened by bark beetles or other causes. Starting in the galleries made by the beetles, it grows into the wood and cambium, loosening the bark, beneath which it produces sclerotia and perithecia in quantity, a characteristic not observed with *C. ips* and *C. piceae*. Experiments showed that the fungus will not grow, nor its conidia germinate, in the absence of oxygen. The thermal death-point of the conidium was found to be a temperature of 54° C. maintained for 5 minutes. In a series of tests made on the efficiency of various disinfectants against the spores and mycelium of *C. pini* corrosive sublimate was found to be the most effective substance. This paper is well illustrated and based, it seems, on a most careful series of observations, so that the further papers promised by these authors on the physiology of this and other species of *Ceratostomella* will be awaited with interest.

In Scandinavia two important papers on the fungi associated with the discoloration of wood pulp have recently been published. From the point of view of the English reader these are particularly useful as the full text is in English. The solicitude of the Scandinavian investigators for English-speaking workers has been remarkable—a few years ago the full text of a long paper on the blue stain of wood by Lagerberg, Lundberg, and Melin[1] was also published in English. The first paper is by Robak (4), who made an exhaustive study of the fungi occurring on ground wood pulp in Norway, and discusses in detail the taxonomic position of the most important species, giving diagnoses of several new ones. He carried out experiments to determine how many of the species isolated are capable of causing stain in pulp. In an endeavour to trace the source of infection at pulp mills he made a survey of the fungal infection occurring in the wood pulp at various stages of manufacture, and of the water and air in the mills, from which he concluded that spore infection in the air is a more important source of contamination than either the timber or the water, and that this source is most serious in mills using a closed system with constantly circulating back water, particularly where this involves the use of large open concentration tanks.

Melin and Nannfeldt (1) working in Sweden have published a long paper on the blueing of ground wood pulp. The first part of the paper contains detailed, illustrated, descriptions of the various species of fungi isolated from wood pulp, and includes a number of diagnoses of new species. The taxonomy of the various species is fully discussed; it will be a matter of regret to many that it has been found necessary to transfer most of the well-known species of *Ceratostomella* to the genus *Ophiostoma*—it

[1] *Svenska Skogsvårdsföreningens Tidskrift*, xxv, 1928.

seems a pity that the laws of nomenclature necessitate changing such a well-established name. The second part of the paper deals with experimental researches on the control of stain in wood pulp. The methods of analysing the fungal flora are described and the relative importance of the various species in causing stain indicated. From a study of the various sources of infection it is concluded that 'interior' infection of the pulp is usually more important than 'exterior' infection during transport and storage of the bales. Most of the infection originates from the 'white water' in which a multiplication of the fungal spores derived from the mill atmosphere takes place.

The influence of various physical factors on the development of fungal stain in pulp is analysed, and it is shown that these are not nearly so important in determining the liability of the pulp to stain as is the presence of certain other organisms, certain yeast-like Hyphomycetes being found to exert a strongly retarding action upon the growth and staining intensity of the blueing fungi in ground pulp. As a result of many practical tests with chemicals for the control of the staining fungi, the following substances were selected for further trials: sulphur dioxide, paranitrophenol, sodium fluoride, and a proprietary antiseptic 'H 146 neu'. The authors conclude that there is a possibility of biological methods of control proving effective: in one experiment a suspension of *Torulopsis* sp. was introduced into the white water so that this contained 5 million cells per c.cm. of the water—the effect of introducing this and similar organisms under mill conditions is now being investigated.

In Russia there appears to be a great deal of work now in progress on the fungal deterioration of wood, but unfortunately much of this is not available for the English reader because it is published in Russian, often without a summary in any western European language. A recent bulletin on injuries to timber caused by fungi, from '*Zniimod*', which is an abbreviation for the 'Central Scientific Research Institute for the Mechanical Working of Wood', contains a number of interesting contributions, some of which deal with blue stain. Miller and Tcherntzoff (2) describe three new species of *Ceratostomella*, *C. comata*, *C. acoma*, and *C. imperfecta*, which are reported to be capable of causing severe staining in softwoods.

In another paper Tcherntzoff (7) shows that the invasion of sapwood by staining organisms is not always followed immediately by discoloration, and that the hyphae may extend for several millimetres beyond the visible signs of stain. This means that traces of infection may remain after the whole of the stained surface has been removed by planing, and this infection may develop subsequently if the timber becomes subject to conditions favouring the revival of the dormant, latent, infection.

In the United States methods for the control of sap stain by means of chemical dips have been developed, and a series of papers by various authors reporting the results of practical experiments have appeared during the last few years, many of them in the *Southern Lumberman*. Scheffer and Chapman (5) state that the chemicals found to be most effective on hardwoods are: borax, some of the organic mercurial compounds such as Lignasan, and certain salts of chlorinated phenols some of which are marketed under the name of Dowicides. Lignasan and Dowicide P. were found to give satisfactory results on pine.

Scheffer (6) in another still more recent paper gives practical details for dipping timber at small mills where only hand-operated vats are available. His conclusions are that pine timber which has been dipped immediately after sawing in a solution of soda at 7 per cent. concentration or in one of the recommended solutions of an organic mercurial or chlorinated phenol substance, can be successfully bulk piled for a period not exceeding four weeks, but that no chemical treatment will control stain satisfactorily

if seasoning is greatly retarded. A good roof and foundation and facilities for free circulation of air are also essential if consistently good results are to be expected. According to this author it is most important that the dipping of pine timber should be carried out as soon as possible after sawing, and in no case should it be delayed for more than two days if damaging amounts of blue stain are to be avoided.

The problem of preventing fungal stain during the seasoning of softwoods and of light-coloured hardwoods is becoming increasingly important as the marketing of these timbers from the tropical colonies develops. While it may be possible in this country largely to prevent blue stain by rapid seasoning alone, yet under conditions of tropical humidity and temperature it is sometimes almost impossible to obtain timber free from stain without using chemical dip treatments, and the experience already obtained in the southern states of America should be of great assistance to those who are attempting to produce prime qualities of those colonial timbers which are susceptible to fungal deterioration.

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(7) Tcherntzoff, I. A.: 'On the Problem of the so-called Latent Blue Stain of Coniferous Timber.' *Zniimod*, i, pp. 129–42, 1934. (In Russian.)

'*Untersuchungen über das Raumgewicht der Nadelhölzer*, I. Grundlagen und vergleichende Auswertung bisheriger Forschungen.' By Dr. Reinhard Trendelenburg. *Tharandter Forstliches Jahrbuch*, Band lxxv, Heft 11/12, 1934. Pp. 649–747; 26 text figs, 4 maps.

Review by B. J. Rendle

IN much of the early research work on timber the terms quality and specific gravity were almost synonymous. It was assumed that the denser a wood is, the better. This conception is, of course, fundamentally unsound, and, although it persists in certain quarters, it is now generally recognized that the density of timber is only one of many factors which determine its usefulness. Specific gravity is in some respects a convenient index of the properties of timber; it is perhaps the most useful single factor for indicating the general quality of a species, but there is a danger of its importance being over-emphasized. It is not sufficiently recognized that specific gravity is itself an expression of a combination of more fundamental characters. Various combinations of physical and chemical characters may produce woods of the same density, but their technical properties will not necessarily be similar. It is convenient to know what approximate relations exist between the specific gravity and other properties of timber

—its strength, durability, working qualities, &c.—but attempts to determine exact relations are foredoomed to failure. They can only result in broad generalizations which, like most generalizations, are of limited application in practice. What may be true of one particular species does not necessarily hold good for all, but this precept has not prevented the spread of numerous misconceptions about the technical properties of timber which it will be the task of timber research workers of the future to dispel.

The paper under review is an exhaustive analysis of a vast amount of data compiled by various workers, mostly on the Continent and in North America, on the specific gravity of softwoods. It is chiefly concerned with the four common European softwoods, spruce, fir, larch, and pine, and these are compared with related species which have been studied in North America. Recognizing the limited value of figures as such for the study of a variable quantity like specific gravity, the author has made good use of distribution curves, which are admirably suited to a comparative study of this kind. By this method the results of specific gravity determinations on several thousand samples of each species are clearly and accurately shown in diagrammatic form. It is interesting to observe how the shape of the distribution curve is characteristic of the structure of the wood in question. The American White pines, for example, whose structure is such that varying conditions of growth have comparatively little effect on the uniform texture of the wood, have a narrow, sharply pointed curve. In striking contrast are Scots pine and the American Pitch pines, with more than twice the range of variation, as shown by the width of their curves, and the broad, flat top instead of a sharply pointed peak. This would be expected from the structure of the wood, which is strongly affected, as regards the proportion of dense summerwood, by varying conditions of growth. An intensive study of individual species seems to show that the variation of Scots pine is mostly due to variation within the tree. This species has very similar curves for all the localities which provided data for the investigation (including some in Russia and Sweden, but excluding, unfortunately, any from near the northern limits of its range). The author's inference that neither environmental conditions nor quality class affect the specific gravity distribution for a consignment of Scots pine may hold good for the localities studied, but would probably require modification if it were made to include the whole range of its natural distribution.

For the rest of the paper, it will suffice here to mention that the specific gravity of the four European species is considered in relation to ecological conditions and locality, silvicultural treatment, structure of the annual ring, and climate. Many of the conclusions are self-evident and most of the others are indefinite. The paper is chiefly of value in collating a lot of scattered data and in providing a guide to the extensive literature on the subject.

'*The Place of Thinning in Wattle Silviculture and its Bearing on the Management of Exotic conifers.*' By I. J. Craib. *Zeitschrift für Weltforstwirtschaft*, vol. i, pp. 77–108. 1933.

Review by James Macdonald

THIS paper by Dr. Craib, the Research Officer in charge of Wattle investigations in the Union of South Africa, demands the careful attention of all foresters. It is based on researches which have been carried out for the past five years into the silviculture of the Black Wattle (*Acacia mollissima*, Wild.), and have resulted in notable advances in the treatment of this species. The wattle, introduced from Australia, is grown mainly for

its bark, which is used for tanning. Until 1928 it had been the general practice to grow this species on a rotation of about eight years, and at the end of this short rotation there were usually about 800 trees per acre on the ground with a mean height of 35 to 40 feet. This system, we are informed, led to rapid reduction in increment and to general stagnation as a result of the intense competition for the available water, and one of the main objects of the investigation was the alleviation of this competition. Dr. Craib has shown that by very heavy thinning in the early stages of the crop it has become possible to obtain a greatly increased production of bark, while a lengthening of the rotation is also likely. Some idea of the severity of the thinnings recommended may be had from one of the tables which he publishes; in this table an original stock of 40,000–60,000 seedlings per acre at the end of the first month is reduced by thinning at the end of the second month to 1,800 plants, while the numbers at the end of one year, two years, and three years, are reduced respectively to 450, 300, and 200 per acre. Craib places the greatest possible emphasis on the need for crown vigour and development, and states that the major thinning operations must be completed before the culmination of height growth. Thinning, he tells us, must anticipate suppression, and it should aim deliberately at reducing production in the first few years in order to improve the quality of the tree upon which subsequent production depends.

In the course of the paper he develops a 'philosophy' of thinning based on his experience in the wattle research, and in the course of this development he discusses the possibility of the application of his heavy thinning to plantations of exotic conifers in South Africa and to stands of European and American timber trees. Much well-directed criticism is aimed at the standard practice in Europe, but it must not be forgotten that in one sense the procedure recommended by Craib is not altogether new even in Europe, because if we consider the European tree which in its behaviour appears to come nearest the wattle, namely the poplar, we find that the best practice on the Continent does not differ very much in its essentials from the practice evolved for the wattle in South Africa. The need for early thinnings in this case is avoided by the widely spaced planting of selected stock, but the subsequent treatment consists of heavy thinnings repeated frequently and in anticipation of any suppression.

To foresters generally the most valuable contribution which Dr. Craib has made is his treatment in this paper of the subject of dominance and suppression. In the systems of classification used in sample plot work, dominance is a relative term because, in the strict sense of the word, we cannot call a tree dominant without implying that somewhere near it is a tree which is being dominated. According to Dr. Craib, and it is here that he makes the first of his important points, this is all wrong, because such dominants may not be really dominant but may actually be extremely suppressed. The words, of course, are being used in a different sense, because by dominance he means freedom from competition from other trees or from the ground vegetation. A tree which, under the old classification, would be described as dominant, would now be called suppressed if its crown development were being hampered by trees around it, while a tree standing alone and in the open might also be suppressed as a result of the competition of the grass. Although the new use of the word dominance is distinguished by the qualifying adjective 'absolute', one cannot help feeling that it would on the whole be better to adopt some other term to describe this new conception. In judging whether a tree is dominant or suppressed, Dr. Craib is guided by the size of the crown and the vigour of the foliage, and he has prepared on this basis an interesting chart by which he classifies the trees in his stands.

In passing it should be said that the criticisms which are made of the system of

classification used in Great Britain are unnecessarily hard. It is stated that 'this or a similar system of tree classification and thinning has no application in wattle production', but if the C_2 grade thinning had been chosen instead of the C_1, which after all is not a heavy thinning even in our slow growing European crops, the author would have found it much more convenient. And in stating that 'in conducting a heavy degree of thinning, say C_2, either must the periods between thinnings be increased and a factor of suppression in the predominants introduced, in order to secure the crown classes necessary for removal . . .', Dr. Craib shows surely that he has misinterpreted the instructions for thinning.

The other point of great importance which is made is as follows: 'The difference between tolerance and intolerance is not that a tolerant species will grow more rapidly under conditions of intense competition than an intolerant one, but that the former will regain its normal growth rate after periods of suppression, whereas the latter will not'. This has not been completely established although Dr. Craib brings in support of his contention a good deal of evidence, but it is, nevertheless, a very valuable idea and is likely to have considerable influence. It is certainly noticeable in this country that poplar plants which have been crowded (or suppressed) in the nursery rarely recover after being planted out, while the difficulty of pulling round overcrowded plantations of larch is only too well known.

Dr. Craib puts forward a good case for treating plantations of exotic pines in South Africa along the lines of his work with wattles, though his estimates seem to be a little optimistic and he faces squarely the principal difficulty—the resulting production of timber of low quality.

In dealing with the wattle he excludes height growth as an indication of vigour because, among other things, it is very much affected by treatment, heavy thinnings leading to a marked increase, and in his comments in the concluding part of his paper on the European Yield Tables he seems to suggest that the same thing applies to conifers under European conditions. But height growth in European coniferous crops is not affected to any great extent by differences in stocking, and it remains a fairly safe guide to the quality of the site. He states that 'there is . . . little foundation for the argument that stands are deliberately kept dense in order to increase the quality of the timber, for invariably thinning on the better sites is less light than on the poorer'. But if height is taken into consideration, as it ought to be, we find, on consulting, for example, the British Yield Tables, that for trees of the same height the better sites are made to carry a greater number of trees than the poorer ground of lower quality class.

In an article like this, written with such gusto, there are bound to be numerous minor points on which the critic can fasten. Nevertheless it is a really important contribution and is likely to have a wide influence, not only in South Africa, but in other parts of the world as well.

Report of the Forester, 1934. United States Department of Agriculture, Forest Service, 50 pp. U.S. Government Printing Office, Washington, D.C., 1934.

Review by Barrington Moore

'IT is an ill wind that blows no good' applies very aptly to the effect of the depression on forestry in the United States. Not only is there no unemployment among foresters, but the demand for their services exceed the supply, and many of them are working under heavy pressure.

The Forester's report reflects the remarkable stimulus which some of the measures

designed to overcome the depression have produced in the field of forestry covered by the Federal Government. As the Federal activities come in contact with those of the states through co-operation, and of private forestry through the leadership exercised by the Forest Service, the report deals not only with the National Forests, but, to a limited extent, with the activities of the states and private owners. Although the most striking developments are attributable to the depression and to the direct personal interest of President Roosevelt, who has practised forestry on his own lands for a good many years, a large share of the credit must go to the Forest Service for having built up, often in the face of bitter opposition, an efficient organization devoted whole-heartedly to the public interest and ready to make the most of the opportunity when it came.

The forests have been a boon to the unemployed in furnishing what the Forester calls 'a huge work reservoir'. The 162,000,000 acres of National Forests, comprising one-sixth of the forests of continental United States, afforded more than 26,000,000 man-days of work in the 12 months ending 30 June 1934. Carefully considered plans indicate the need of 20,000,000 man-days annually on the National Forests for years to come. The bulk of the National Forests comprise the less accessible mountain lands which were left after the more desirable tracts of timber had passed into private ownership before the policy of setting aside the remaining publicly owned lands for conservative use was inaugurated after 1890. It is therefore easy to see how much work is required in building roads, trails, telephone lines, look-out towers, &c., to protect the forests from fire. This work, which had been proceeding at a painfully slow pace, was enormously accelerated by the emergency expenditures for the Civilian Conservative Corps, about 350,000 young men in camps of about 200 each, scattered over the entire country, by the Civil Works Administration, and by the Public Works Administration. In addition to the requirements for fire protection there is a great deal to be done in planting areas denuded by fire or reckless cutting, in improving stands by releasing the more valuable species from competition, by thinnings, &c., as well as in controlling insects and disease. For example, the White pine blister rust (*Cronartium ribicola*) has spread to the West and seriously threatens the valuable stands of Western White pine (*Pinus monticola*) in Idaho.

On the privately owned forest lands there is also urgent need for a vast amount of work in connexion with protection from fire, replanting devastated areas, control of insects and disease, stand improvement, &c.

The efficiency of the Forest Service organization for fire protection is shown by the fact that, although the season was one of the most dangerous ever experienced, the area burned was held down to less than 0·1 per cent. of the total area of the National Forests. This is partly due to the crews of men working in the woods, and therefore available for fire suppression. There were 17 men killed while fighting fires. Lightning is still by far the largest cause of fires, setting 41 per cent.; the next largest cause is smokers, with 21 per cent.

The large increase in purchases of forest land by the Federal Government had only begun during the period covered by the Forester's report, which shows 574,025 acres purchased. By December the £6,000,000 of emergency funds allotted by President Roosevelt had made possible the purchase of 6,953,918 acres of forest land in 18 months as compared with 4,532,698 acres purchased during the past 20 years.[1] This is a beginning toward carrying out the recommendation of the Forest Service in the Copeland Report, that eventually 224,000,000 acres of forest land should be acquired in addition to that already publicly owned.

[1] *American Forests*, vol. xli, No. 1, p. 31, January 1935.

The policy of acquiring only cut over lands has been modified to the extent of permitting the occasional purchase of lands bearing mature timber. It has thus been possible to buy a few of the now rare tracts of virgin forest in the East. These will be preserved for research and as examples of the undisturbed action of natural forces, so will be of inestimable value for the future guidance of silvicultural practice. Thus it will be possible to work with Nature instead of struggling against it, as has too often been done by foresters, with disastrous consequences.

The report devotes to research the rather considerable amount of space which the importance of the subject warrants, but has not always received in official reports. The results of past research, which at the time seemed beyond the possibility of application under prevailing conditions, are now vitally needed on account of the conservation article in the lumber code, the emergency conservation work, and other activities. Some of the more important results of research are briefly described. Of special interest are the results in the economic field, notably the work of the Forest Products Laboratory. Improved methods have been developed for seasoning and preserving wood, for increasing its fire resistance, and for giving it greater strength and usefulness in houses and other construction. Much work has been done on the making of paper and of fibre containers. This forest products work constitutes a promising counter attack against the campaign of the wood substitutes which has seriously cut into the demand for timber, and has even discouraged many foresters to the point of making them feel that efforts to check forest devastation were unnecessary because there would soon be so little demand for wood.

The report gives the usual figures on the amount of timber sold and cut from the National Forests, the number of cattle and sheep grazed, area planted, recreational use, including a census of big game animals, and itemized costs and receipts. The amount of timber cut and sold increased over the previous year, though it is still far below the possible yield of the National Forests, in contrast with the private forests, which are still being heavily overcut.

Pot Culture Tests of Forest Soil Fertility. By H. L. Mitchell. Pp. 138; 23 tables, 11 text-figs., and 10 plates. The Black Rock Forest Bulletin No. 5, 1934.

Review by R. N. Aldrich-Blake

THE author of this paper is convinced of the inaccuracy of direct chemical analysis as a measure of the fertility of soils, because only a limited portion of the total quantity of any essential nutrient in a soil is available to plants grown therein. The various chemicals used for extraction of soil nutrients can imitate but crudely the absorptive powers of plant roots. He therefore sets out to assess the ability of forest soils to supply the essential nutrients, nitrogen, phosphorus, potassium, and calcium, by an adaptation of Neubauer's biological method. The principle is to accept the mineral content of a plant grown in a soil as the best measure of the mineral supplying power of that soil. If quantitative results be desired a standard for comparison must first be secured by sand culture work. All essential nutrients save one are supplied in quantities non-limiting to growth, and the amount of this nutrient is varied. The amount of this nutrient present in the plants is determined, and a graph is drawn showing the relation between amount of available nutrient and amount thereof absorbed. With this standard established, the soils are tested by growing plants therein, determining the amount of the particular nutrient in the plants, and relating this quantity to figures read off from

the standard graph. The soils are placed in pots, and receive a supplementary supply of all essential nutrients other than that under study, in order to ensure that the supply of none of these should be limiting to growth. If only qualitative comparative results be desired the sand culture work is not required.

By the use of this method four local forest soils were tested, quantitatively as regards their power of supplying nitrogen, qualitatively as regards their power of yielding phosphorus, potassium, and calcium to seedlings of White pine. It appeared that nitrogen supply must have been a potential limiting factor to growth in all four soils, for the richest supplied only 24 per cent. of that quantity which gave the highest yield in the sand culture experiment. The four soils were ranged as regards nitrogen supplying power in an order which failed to tally with that obtained by direct analysis of the soils for ammonia nitrogen, nitrate plus nitrite nitrogen, organic nitrogen or total nitrogen.

The author's method of correcting plant weight for variations in seed weight has already been criticized in a note by the reviewer in the present number of *Forestry*.

A most useful new technique for watering plants in sand culture is described. The solution drains out of the pot through a basal tube into a stoppered flask set below, and is forced back into the pot by increasing the air pressure over the solution in the flask by a pump. Thus the plants can be watered without moistening the superficial inch of sand, and this must be most valuable in preventing algal growth, which may destroy the accuracy of sand culture work. Moreover, by connecting the pump with several flasks, several pots can be watered simultaneously, and valuable time is thus saved.

In conclusion it may be said that the principle of this method is eminently sound, especially when applied to forest trees, for most of these are mycotrophic, obtaining a large proportion of their mineral nutrients through their symbiont fungi, whose enzymatic activities must surely be more difficult to imitate by extraction of the soil by chemicals than the absorption by uninfected roots. But there are two possible sources of error. The first, mentioned by the author, is due to the use of unbalanced solutions in the soil culture experiments. In one case a soil receiving only distilled water produced heavier plants than the same soil receiving all nutrients except nitrogen and phosphorus. A second error may be incurred through the inevitable mixing of the soil horizons when soil samples are collected. As Hesselman has shown, electrolytes derived from the mineral portion of the soil accelerate nitrification of the nitrogen in the humus layer, and the nitrogen supplying power of a soil collected and placed in a pot may be thus greater than that of the same soil *in situ*. It is interesting therefore to note that the author appears to contemplate extending his work to the analysis of seedlings grown in natural soils in the forest.

NOTICES

The Practice of Silviculture. By Ralph C. Hawley. Third Edition. Chapman & Hall, London. Price 20*s*.

THE great development in forestry which is taking place in the United States of America under President Roosevelt's administration is reflected in the increased flow of American forestry literature.

Hawley's *Silviculture* is well known, and this new edition will be welcomed. It covers a very wide field, and consequently the treatment is not detailed; it is a general textbook on silviculture and protection, and not an exhaustive exposition of any particular aspect of these subjects. Emphasis is placed on technique rather than on theory.

Over one-third of the volume is taken up with methods of regeneration—artificial and natural—the principal silvicultural systems being described. There are three chapters on intermediate cuttings; thinning is dealt with more adequately than in the second edition, and this section is as good a general account of thinning practice as is available in English. There is a short section on pruning.

A large part of the remainder of the book deals with fire protection, with shorter sections on protection against insects and fungi.

The general balance of the book, with little emphasis on methods of artificial formation and great emphasis on fire protection, makes it not altogether suitable as a text-book in this country. It will repay study, nevertheless, principally for the descriptions of the applications of silvicultural and protection technique to American conditions.

Management of American Forests. By D. M. Matthews. American Forestry Series. McGraw-Hill Publishing Company Ltd., London, 1935. Price 30*s*.

AT one time American forestry text-books drew their data largely from European sources. That day is past, and this is to be welcomed because the conditions, particularly in the field of management, are entirely different. Professor Matthews, before entering the academic fold, was in the forest department of British North Borneo, and a manager of a timber company in the U.S.A. One might expect something unorthodox in the way of a forest management text-book, therefore, and one has got it in this volume. It is not improbable that some teachers of forest management will not recognize it as a text-book on their subject.

Whether one agrees with the scope and teaching of this book or no, its realism can be welcomed. The condition of many of the forests and areas of forest land in all parts of the world outside continental Europe makes it necessary to consider the subject of forest management unbiased by orthodox European views. That does not mean that these views are wrong, but that they are applicable to conditions which will exist elsewhere only in the distant future, if at all.

Until now American forests have been treated as a wasting asset. The problem of management is to organize them on the basis of continuous production. The author does not consider that the relatively rigid working plan is appropriate to secure this. The use of preliminary and detailed reports is advocated in which relevant data regarding the property are stated, and alternative possible lines of action discussed. 'The line of action adopted will crystallize into a definite plan as management proceeds and may or may not be definitely committed to paper.' 'The business records of the property under successful management constitute as elaborate a plan as is likely to be required during the first decade of development.' The importance of business and financial rather than technical considerations are stressed. Such theories are known to the orthodox to be full of pitfalls, but are worthy of detailed considerations for appropriate conditions.

As regards general lay-out, the book is divided into two parts: Part I, the Foundation of Forest Management, and Part II, Financial Aspects of Forest Management. Part I contains chapters on: The growth of the tree and the stand; the effect of site and stocking; rotation and silvicultural methods of treatment; the growth and growing stock of the regulated or normal forest; actual growing stock; regulation; adaption of regulatory methods to American forests; the growth and growing stock of selection forests; the adaption of normal yield table data to selection forests; and field examination. Part II deals with different branches of forest finance.

Identification of the Commercial Timbers of the United States. By H. P. Brown & A. J. Panshin. American Forestry Series. McGraw-Hill Publishing Company Ltd., London, 1934. Price 18*s*.

THIS book was the first of the American Forestry Series, the object of which is to present 'the best practical and scientific data available in different branches of forestry and to recount the results of experience and to suggest new points and methods which may help the practising forester to evaluate the conditions under which he is working'.

America has recently produced more than one outstanding book on the identification and structure of timber, and this book invites comparison with Record's, also published last year and reviewed in *Forestry*, viii (2). The book under review does not deal so extensively with wood anatomy, only 25 pages being devoted to gross and minute anatomy. It will appeal, therefore, to the general forest officer rather than the specialist, but the former should find it an excellent text-book.

There are two keys, one based on gross and one on minute features. Then follow descriptions of woods by species, which are also divided into general characteristics and minute anatomy. There are 60 plates illustrating the features of the timbers.

This book has been written in that simple way which requires great knowledge of the subject. As we grow so many American trees, it is worthy of the attention of British foresters.

Forest Mensuration. By D. Bruce & F. X. Schumacher. American Forestry Series. McGraw-Hill Publishing Company Ltd., London, 1935. Price 21*s*.

THE authors consider that it is better to teach students to use tools rather than to perform work; in this case the use of cross-section paper, simple and harmonized curves, sample plots and strip surveys, and hypsometers, &c., rather than the preparation volume tables, growth studies, and yield tables. Theoretically this is true, but unfortunately many are attracted to forestry because it is a biological and not a mathematical subject, and anything beyond the simplest mathematics is a stumbling-block. To such, the performance of work is perhaps a better training.

Forest mensuration is the same all over the world, hence this text-book has not got the national limitations which other volumes in this series have. It treats the subject from a fresh angle, and while there is much emphasis on part of the subject to the detriment of balance, this text-book is a valuable addition to forestry text-books.

Part I, on direct measurement, deals with the measurement of diameter, height, volume, &c., and follows conventional lines.

Part II, dealing with direct estimate by sampling, contains much that has not usually been included in books on forest mensuration, and for which one had to go elsewhere. There are chapters on averages, measures of dispersion, standard error, applications of the normal curve, and sampling.

Part III is on indirect estimate based on one or more independent variables. Here are dealt with: graphical methods, free-hand curves, least squares, transformation of curves into straight lines, least squares with two independent variables, alinement curves, &c.

Part IV discusses the determination of the growth of the tree, growth of even-aged stands, and all-aged stands.

The authors present the subject clearly and do not use more abtruse mathematics

than is necessary. When they leave mathematical ground they are less illuminating as, for example, in the discussion of site quality: when dealing with permanent sample plots, while they refer to weather cycles as a variable, no mention is made of soil heterogeneity and methods to deal with it. It is unfortunate that no reference is made to plot technique and there is no discussion of analysis of variance in small samples in its application to this subject. Having regard to the professed scope of the book this should have been included, because it is no further from the average student's requirements than much that is included. Every book, however, has its limitations, and this book undoubtedly marks an advance in the subject.

Dictionary of Terms relating to Agriculture, Horticulture, Forestry, Cattle Breeding, Dairy Industry, and Apiculture in English, French, German, and Dutch. By T. J. Bezemer. George Allen & Unwin Ltd., London. Price 25*s.*

THIS dictionary has been prepared by Professor Bezemer with the help of a number of Dutch colleagues. It is a good technical dictionary as regards forestry, the only drawback being its bulk and price. It is a pity that the terms relating to, say, forestry and horticulture had not been published separately.

Forestry Commission Utilization Series, No. 1. *Report on the Demand for Timber for Box and Packing-case manufacture in Great Britain.* H.M. Stationery Office, Adastral House, London W.C.2, 1934. Price 9*d.*

THE Inter-Departmental Home-Grown Timber Committee decided to prepare and publish from time to time reports on the timber requirements of different industries. This is the first of such reports. The subject is dealt with regionally. The requirements as regards kind, size, grade, and seasoning of timber for boxes is given with prices paid. The use of home-grown timber is noted, and the views of users on its suitability recorded. There are also sections on box and packing-case dimensions and the trade in box boards. The inquiry brings out the fact that home-grown timber is much more widely used for boxes and packing cases in Scotland than elsewhere in Britain. It is estimated that 20 per cent. of the requirements of Scotland, and 40 per cent. of the consumption in Aberdeen, is home-grown. The principal criticisms of home-grown timber are: knottiness, inadequate seasoning, price, unreliable supplies, bad sawing, and heaviness. Box making is not a high-grade form of utilization, and it should be possible to supply a greater proportion of requirements from home sources.

Forestry Commission Utilization Series, No. 2. *Report on the Demand for Timber in Coal Mining in England and Wales.* H.M. Stationery Office, 1935. Price 1*s.* 3*d.*

THIS is the second of this series. It follows the same lines as the first, giving the requirements, specifications, and price of mining timber in the principal coal-fields. It is stated that Scotland was not included in the scope of the inquiry, because the position had already been examined and steps taken to secure co-operation between growers, consumers, and merchants. While this is so, the data are not available to many interested, and its publication would have been welcomed.

As regard pitwood—the principal category—the average length of prop used increases from the north southwards from Northumberland where the coal seams are narrowest.

A large proportion of the requirements are imported from Baltic sources in all coal-fields except South Wales, which is supplied from France and Portugal. There is a widespread belief that home-grown props are unsatisfactory and dangerous, and this belief can frequently be traced to war experience when conditions were difficult. It is not supported by systematic tests, and there appears to be no reason why home supplies could not be used in increasing quantities, if the cost of transport to consuming centres bore a more reasonable proportion to the value of the material.

ADDRESS TO THE SOCIETY[1]

BY SIR ALEXANDER RODGER

IN the course of nearly forty years' work in forestry, I have been struck by the very varying importance that the subject has attained in different countries. In the Service in which I spent most of my time, we have a very large area of forests which are a most valuable asset for India, but the forest sense cannot be said to exist among the masses of the population, except perhaps in Burma, where the great teak forests are certainly a factor which enters very largely into the life of a considerable part of the population. In fact they are so much a part of their life that they are accepted as a matter of course as much as the sun and the air.

One can imagine that the forest is a very vital part of the life of the inhabitants of the wild parts of South America, Siam, West Africa, the Congo, and many other wooded parts of the globe, and it must have been equally so to the North Americans of the old days.

In those countries in Europe where science has attained its greatest advance, forestry has reached a point of development where it has assumed its place as a very important and well-recognized feature of national life, especially in Germany, France, Switzerland, and Austria. There is little need for propaganda in such countries because every one has been accustomed to hear forests talked of as important and permanent features of national life. In the United States, which used to have many millions of acres of splendid forests, strenuous efforts are made to interest the citizens in the forests which remain, especially by using them as a means of healthy recreation. In Pennsylvania there is said to be only one-thousandth part of the area of the original forests left, but the State now owns over a million acres of forest land of some kind, and every effort is made to attract the population to these woods. I quote here from an article by Mr. Summers in the *Scottish Forestry Journal* for March of this year:

'The kinds of areas to be set aside for recreation have, in America, been separated into five types. The first type is the "Superlative Areas", or those with unique scenic values. The second is the "Primitive Areas", that is tracts of old growth timber in which human activity has never upset the normal process of nature. The "Wilderness Areas" are those without permanent inhabitants or means of mechanical conveyance, through which one can travel for days without meeting another party. The fourth is "Roadside Areas" or timber strips adjoining important roads, and the fifth type is "Camp-site Areas" or those places set aside for campers. For the establishment of such areas, Federal and State laws will need to be passed, and protection against fire, elimination of billboards, and provision of suitable plans for administration must be undertaken.'

Although we may not altogether understand this somewhat flowery description of wooded areas, which certainly differs very considerably from what most of us write and read on forestry in England, still it shows that there is a strong

[1] Delivered at the Eighth Annual Meeting of the Society, held in London on 31 May 1935.

desire to interest the public in the woods and to induce them to make use of them.

In our own country there is at present little of this evidence of a forest sense, or a desire to cultivate it, by interesting the public in the English woods. Many people have never heard of the Forestry Commission, and some are actually hostile to its measures. In England, you will always find a number of people who have little to occupy their time and are too apt to object to anything new that is proposed for the simple reason that it has never been done before. You cannot propose to build a road, a bridge, a reservoir, or anything else, but some one is sure to write to the papers to say that you are ruining the country, and forestry has received its full share of this unenviable publicity. You will all have heard how the Forestry Commission has been attacked for daring to wish to plant trees in the Lake District, and you will also have read that an informal committee has been constituted composed of members of the Council for the Preservation of Rural England (commonly known as the C.P.R.E.) and members of the Forestry Commission. As announced in *The Times*, the object of the informal discussions of this committee is to discuss matters of outstanding interest regarding forestry and afforestation in relation to the amenities of the countryside. A leader in *The Times* of 11 May says that the Forestry Commission is a body which has both the power and the desire to increase the beauty as well as the wealth of the country.

I hope you will pardon a further quotation from the same leader because the matter seems to me of the greatest importance, and it has been well expressed in the quotation.

The Times says:

'To judge from the many letters published here during the past six months, three questions are likely to take up most of the Committee's attention in the early days. Those three questions are the proportion of hardwood to softwood in planting; the introduction of exotic trees; and the afforestation of wild lands. All three questions, no doubt, would be much less acute than they are if Professor George Trevelyan, and many another, could have their way and the Government would give the Forestry Commission a great deal more money and a great deal more power than it has now, and if the Government would also make it easier for landowners to plant hardwood timber in such quantities that all anxiety about its scarcity would be allayed. But this, under present conditions, is to cry for the moon, where there are no trees at all, and the Committee will have other things to do. It seems unlikely that the lurking dislike of 'exotic' trees will take up much of their time. It is pedantic and ill-founded on fact, and there is no reason, economic or aesthetic, why the roadside and the countryside should not benefit, where they can, by beauty and utility that have been very welcome in the garden.

'It is on the other two points that the public will most welcome the feeling of confidence aroused by the promise of discussion. For one thing the C.P.R.E. can be trusted to relieve a nervous public of groundless fears that its wild open spaces are going to be planted over, that breeds of sheep are going to be exterminated, that money is to be thrown away on planting trees where no trees can grow, and so forth. There is evidently need of some re-assurance on these points; and the presence of the C.P.R.E. at

the council board will be a guarantee that there is no cause for alarm, and that, if certain areas must be planted, the afforestation might be combined, by methods that could be thought out, with the permanent preservation of the remainder for the public benefit. On the question of hardwood against softwood there will also be a feeling of relief. The Forestry Commission has a very difficult task to pursue and is very much hampered in pursuing it—chiefly by lack of means. On such lands as it has at disposal the planting of hardwood timber as a commercial proposition is by no means easy; and, when nine-tenths of the timber used every year in Great Britain is softwood, it must follow its plain duty of providing softwood for the future in great quantities. But the public may be sure now that the Forestry Commission's pretty steady annual increase in its planting of hardwood will be encouraged to the highest point, and that it will have strong and wise backing in its struggle to carry on its business, without flouting the public love of the old, familiar trees, or throwing away chances of putting land to its best ultimate uses, or wantonly changing the face of England.'

With all of this the members of our Society will, I am sure, heartily agree. We are fortunate in having among our members with us to-day representatives of the Forestry Commission, the Indian Forest Service, the Colonial Forest Services, the Institute at Oxford, the Research Laboratories at Princes Risborough, Kew Gardens, the University of Cambridge, and the College of Estate Management, and, although our interests are primarily technical and professional, I feel that we can do a great deal for our country if we endeavour to cultivate the forest sense among people we meet. Cinemas and lectures can no doubt do much, but I feel that we, who belong to a professional forestry society, can do our part by talking to people, and putting our point of view before them in a rational and attractive manner. I am sure that all of us feel that if we can carry this out we shall be helping both our profession and England.

RADIAL GROWTH AND EXTENSION GROWTH IN THE TREE

BY PROFESSOR J. H. PRIESTLEY

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INTRODUCTION.

IN 1932 a brief account was given in *Forestry* (5) of the work proceeding in the Leeds Botanical Laboratories on problems connected with tree growth. The Editor has asked for a statement of the progress of this work, and under the above title it may be possible to give a brief indication of its development, or lack of development, on lines that may be of some interest to foresters. More technical accounts of some of the work have been published elsewhere and are cited at the end of the paper so that reference may be made to them if further details are required. The main problem under investigation has still been the curious contradiction in the behaviour of the tree in respect of its two characteristic modes of growth. As the shoots extend from the buds in spring, we recognize in the process of extension growth a continued *upward* growth of the tree. From the moment the young seedling bursts through the soil, throughout the vigorous life of the sapling, and the slower, maturer, upward growth of the forest tree, it is natural to think of the tree as 'growing up'. On the other hand, when we turn to the process of growth in girth, which converts the slender sapling into the massive bole, every further observation has only strengthened the conclusion which was drawn from earlier observations and emphasized in the 1932 paper. The new radial growth of twig, branch, and trunk does not commence until the new season's growth has begun in the buds, but then it starts on the twig beneath the growing bud and spreads from thence down the tree. So far then as radial growth is concerned, it is equally true to say that the tree 'grows downward'.

This remarkable relation between extension growth and radial growth was particularly emphasized in the 1932 paper as it must unquestionably have the closest relation to the problems of the forester, which ultimately centre around the possibility of controlling this process of radial growth in such a way that the annual increment of wood may be added so as to give the most valuable yield of timber under the most economic conditions. If radial growth depends on the growth of the buds above, then its control must lie, in the first place, in those processes of forest management which either encourage or suppress the growth of the buds in the forest canopy.

Although at first sight this view of radial growth, that the tree grows in girth downwards, may seem topsy-turvy, yet further consideration suggests that it is very reasonable. It is the fundamental fact about the green plant that the organic food material necessary for life and growth is made in the green leaf when exposed to sunlight. Water and salts may be drawn in at the roots,

carbon dioxide from the air through the stomata on the leaves, but unless these raw materials are built up into sugars, proteins, &c., in the manufactory of the green leaves exposed to sunlight, these supplies would never be able to maintain the complex processes of growth which proceed in the buds and in the cambium. It seems natural, then, since these growth processes are maintained by the supplies received from the leafy canopy, that they should depend upon initial impulses derived from the shoots in the light, and in this sense, growth should proceed downwards. However, the correlations which exist between leafy canopy and growing regions are far more complex than might be supposed from this brief statement. In the first place, whilst the adult leaf supplies food to the tree, the same leaf had to be supplied with food from the tree during its first formation. Yet, it is not the adult leaf, apparently, that is directly associated with the initiation of radial growth on the twigs; in fact this radial growth proceeds most vigorously at the time when the buds are first expanding and the young leaves are drawing upon the food supplies. Perhaps further study will throw light upon this curious correlation between leaf growth and radial growth.

A second unsuspected correlation of extension growth and physiological function has also emerged and is gradually becoming more intelligible. Leaf growth and radial growth may well be linked in connexion with movement of manufactured food, but at first sight there seems no reason why water movement should be controlled by these processes initiated in the topmost branches, far removed from the soil. Yet, as emphasized previously, only growing shoots remain full of sap, whilst shoots on which the buds fail to grow soon lose their sap and dry out. A closer analysis of the linked processes of extension and radial growth has partly revealed a mechanism which must be of vital significance in water movement in the tree. It is at this point that we may try to add some detail to the account of growth in the tree given previously. Then if we continue to consider the linked activities of leaf and stem, we may find some suggestion emerging as to the manner in which the adult leaf may be exerting a profound influence upon the continuance of the process of radial growth.

VESSEL DIFFERENTIATION IN THE HARDWOOD.

The radial growth in the tree may be studied by means of the 'strip' method, which was described in an earlier paper (7). This method has much to commend it to the forester because, apart from the use of the microscope, the technique is extraordinarily simple, whilst the possibilities of the method are enormous. It has thrown quite a new light upon that central problem of radial growth in the hardwood, the development of the vessel. In the 'strip' method, the bark is removed from the tree when it 'slips' in the spring. The bark will then separate from the wood in the region of the cambium. Its ready separation is due to the fact that when the cambium begins to grow again in spring, its cells first swell with water, the living contents become practically liquid, and, as the walls surrounding these liquid contents are very thin, the layer can no longer resist any tearing force which tends to separate the bark from the

wood. Soon after swelling, the cambium layer begins to grow, and the first processes of growth are always the same. In the winter condition the cambial cylinder is only one cell deep in the radial direction, and the swelling of the cells in the spring leads mainly to expansion of the cells in this direction. This is followed by division of the cells into two by walls parallel to the surface of the wood, so that the cells resulting from the division both lie on the same radius of the stem. Both these cells may divide again and in this way the cambium, originally one cell thick, may become in the growing season a layer several cells deep in radial thickness. However, it is always true that of these files of living cells of the cambial region, the outermost ones at first are the most actively growing, whilst the inner ones cease to grow and begin to change and differentiate in course of time into new wood elements. Thus in the spring the cambium is giving rise to new wood only; no new cells are being cut off towards the outside and consequently at this time no new cells are being added to the phloem or bast.

If the bark is torn from the tree after this process has proceeded for a short time, the bark will still tear away in the most active region of the cambium. Therefore it tears along the tangential plane in the outermost layer of new cells, and leaves on the surface of the old wood the new layers of cells which have just been formed from the cambium and which are going to become wood elements.

This sequence of events explains the 'strip' method, which simply consists in peeling these soft tissues off the hard surface of the old wood after a piece of bark has been removed. They can be stripped off with a pocket-knife from a twig or with a small screw-driver when a narrow incision has been made through the thick bark of a tree trunk. No technique could be simpler, but the strips thus removed—spread out on a microscope slide in water or suitably fixed and stained and then mounted as permanent microscope preparations—supply a host of new facts as to the processes of cambial activity and wood development. The cells cut off from the cambial cells by longitudinal tangential divisions are at first simply replicas of the cambial cells themselves in tangential view. Strips taken soon after growth has started thus supply valuable information as to the form of the cambial cells, whilst the ease with which the strips separate from the wood and the comparative thickness of the strips, when compared from different positions on branch and trunk, throw a flood of light on the progress of radial growth throughout the tree. It is thus that the basipetal progress of radial growth has been followed with comparative ease in a number of different trees, and many data have been accumulated as to the time of initiation of the process beneath the buds in different species, and the time that it takes to spread from the buds to the base of the trunk (7).

Yet, whilst the strips are still so thin that their close study under the microscope is possible, within them changes have begun which will end ultimately in the production of new wood elements. In the softwood, the various stages in the differentiation of the long, pointed-ended tracheids may be followed, but it is a still more intriguing study to follow the processes of change in the hard-

wood, where vessel differentiation may be seen to begin, and can be followed through to its completion. In the thin strips which are removed in the early stages of radial growth only one new vessel may as yet be visible in the thickness of the strip. It is then possible to follow this same vessel along the strip, and there is really no limit to the length of the strip which may be obtained by this method if care is taken in the process. Strips as long as the microscope slide are easily removed, and it is rather the inconveniences attached to their mounting and examination than the manipulative difficulties which, in practice, usually confine the strips to about this length.

In all such strips, the same vessel may be followed with ease for the whole length of the preparation. Now as the vessels can be examined from the same tree in strips made at successive intervals of time, or as they can be sampled practically throughout the whole tree at the same time by strips taken from various positions on trunk and branches, a new method seemed available to follow the process of vessel growth and differentiation. During the last two years considerable attention has therefore been paid to this problem. The results are as yet scanty, but they are perhaps as unexpected as they are interesting. The essential characteristic of a hardwood vessel is that it is a pipe built out of a file of originally separate cells, each of which was completely surrounded by its own cellulose wall. It is as if a pile of boxes had been built up end to end, and then their ends had all been knocked out so that the whole pile became one intercommunicating tube.

In this case the original separate cells have been cut off from the cambium sheet, and it was pointed out previously (5) that the different behaviour of the cells in the hardwood as compared with the softwood probably arose from the fact that in the hardwood, these cells, like the cambium cells from which they were cut off, were comparatively short and blunt-ended. As a result, when they swell up with water, as they do after they have ceased to divide, they throw so much strain on the thin walls covering the blunt ends between cell and cell in the longitudinal file that these walls perforate, and the file of cells now becomes the series of segments of the future pipe or vessel.

When the strip method was devised, an intensive study was made of the strips taken from hardwoods in the spring with a view to finding stages in the process of vessel development. As has been reported elsewhere (8), one remarkable result has been to show that practically no stages can be found between the tissue just beginning to expand and the file of perforated elements in which the cross walls have disappeared and are only represented by a rim at the inner margin of the pipe at the points where each segment of the vessel adjoined its neighbour. This fact can only mean, after the close study that has been given to such material, that the perforation of the cross walls of the vessel-segments is almost an instantaneous process. Text-books have talked of digestion of these walls and of their gradual absorption. There can be no question that such terms are misnomers. The cells expand rapidly with water; at a given moment the cross walls evidently fail to stand the strain and, as soon as a rupture appears, the thin cross wall of each vessel-segment shrinks back to

a thin line around the inner edge of the vessel, where it may later be recognized as the rim of the vessel-segment. At this stage of vessel expansion all the walls are thin. It has been possible to macerate strips of young tissues (in 5 per cent. chromic acid) so that the vessel-segments may be seen freed from the tissues around, when their walls are seen to be exceedingly thin; at this stage also there are no signs of the thickenings between the pitted areas which form such characteristic patterns later (8).

But a more disconcerting fact is that not only can no stage be seen between just expanding cells and completely perforated vessel-segments, but also throughout the length of the same vessel, no difference in stage of development can be seen. In such strips the same vessel has been followed for several inches and through large numbers of vessel-segments, and this same result is always obtained. Not only then does the perforation of an individual vessel-segment take place very rapidly, but all the segments of the same vessel apparently perforate at about the same time. When these observations are extended to the case of the ring porous trees, the amazing nature of the process we are studying becomes very apparent.

Strips are so readily obtained from any region on the tree that it seemed practicable to follow the downward differentiation of the vessels by removing strips from branches and from top and bottom of the trunk of well-grown trees at regular intervals of time. In the ring porous trees, however, ash, elm, wych elm, oak, sweet chestnut, and laburnum, not only are young vessels to be found on the twigs early in April, but observations on successive days have so far failed to trace any stages in the differentiation of these vessels down the trunk. In spite of repeated observations at different heights on the trunk in all these trees, it has proved quite impossible to trace a gradual spread of vessel differentiation down the trunk. Within a few days of the detection of vessels on the twigs, they are always found on the trunk, and when young vessels are found at a height of 15 to 20 feet on the trunk, they are also present at the base of the trunk. Although the activity on ring porous trees commences so early in the season and at a time when the buds show hardly any signs of movement, there is no doubt that the renewal of cambial growth which precedes vessel differentiation is a process initiated in the buds; twigs on which the buds are not moving contribute nothing at all to this activity on the branches and trunk beneath.

It is really this rapid downward spread of cambial activity which is the first salient difference between ring porous and diffuse porous trees. In the diffuse porous trees, although the buds may commence to push at as early a date, and although they are usually earlier in unfolding the leaves from the bud than the ring porous types, yet the renewal of cambial activity beneath the buds is slower, and its basipetal spread down the trunk is also very much slower. In such trees, it is quite possible to find vessels in higher regions of the main branches and trunk days, weeks, or even in some cases months, before the vessels are found at the base of the trunk. On the other hand, in cases of such slow basipetal differentiation, it is still true that in the individual vessel no

stages in differentiation can be seen throughout its length, though this may extend to many inches or feet.

The natural conclusion seems to be that the factor controlling the differentiation of the vessel is the rate at which cambial growth is being resumed in a basipetal direction. When the cells of a file expand with water and by bursting the cross walls coalesce into one continuous vessel, such a process cannot proceed farther in a longitudinal direction than the file of cells which is in a suitable condition to undergo such differentiation, that is, the cells must have been recently formed from the cambium, they must be at the same stage of development, and must have living protoplasmic contents surrounded by thin walls. The rate at which cambial activity is resumed down the tree thus seems to be the factor which determines the length of the vessel.

However, if this argument is carried back to the ring porous tree, it leads to a startling conclusion which so far has proved beyond the possibilities of the strip method to verify by actual observation. The essential characteristic of radial growth in the ring porous tree is that it spreads very rapidly down twig and branch right to the base of the tree. As soon then as vessel differentiation begins in the new tissues, the file of cells which expand thus are in contact longitudinally with cells at a similar stage of development right to the base of the trunk. Then applying the same argument, vessel differentiation may be expected to occur, without any interruption, in one continuous file of cells from the slender branch to the base of the trunk, however tall the tree. Whilst vessel differentiation has been followed through a length of about 6 feet on the trunk of ash without any apparent difference between the segments of the file forming the vessel, it is not practicable to follow the same vessel in strips of 100 feet or more in well-grown trees, but every additional line of experimental attack that can be brought to bear on this problem seems to support this remarkable conclusion. It was hoped to reach a final decision as to the length of the vessel by the method of injection. As already described, the fully differentiated and lignified vessels usually have contents under less than atmospheric pressure so that when such vessels are cut open under fine suspensions such as that of the carbon particles in indian ink, they readily inject. Injections of this kind have been followed for some 30 feet, but when the liquid ceases to move, the end of the vessel has not been reached. A close examination of the experimental technique has shown that it will be by no means easy to reach the ends of vessels by this method. Calculations of the length of vessels based upon the speed of entry of the liquid into the vessel, and the rate at which the velocity diminishes as the column rises, suggest that the vessels in ash are at least as long as the tree. Also from the anatomical side an attempt has been made to recognize the end of a vessel, and in this direction W. R. C. Handley has made considerable progress (4). Vessel-ends can be found in almost any sample of macerated wood of diffuse porous types, but they are exceedingly rare in ring porous woods. They have been identified in oak, ash, and laburnum, and the type of ends thus disclosed may help to explain the curious result, from the calculations of the reduction in velocity of injection,

that the vessels into which the liquid is rushing often appear to be longer than the tree.

These problems are still under examination, and it will require at least the continuation of observations through another season before very definite statements can be made as to the actual length of vessels; there can be no doubt, however, that they are very long in ring porous types, and there seems little doubt that this length is correlated with the rapid spread of cambial growth down the trunk of this type of tree. It appears also that in one of these long vessels the expansion along the whole length must be very rapid and almost simultaneous. The increase in volume we are concerned with here is by no means negligible, a cell originally about 0·05 mm. in diameter expands in the central region of the trunk to a diameter of the order of 0·5 mm., so that the increase in volume may be as much as an hundredfold. Practically all this increase is due to intake of water, and apparently takes place throughout great lengths of trunk practically simultaneously. The only possible source for this water to come from is the old wood, over the surface of which the new tissues are lying. Clear evidence that the water is obtained in this way is supplied by injection experiments, because if the surface of the wood is cut under indian ink as these new vessels begin to differentiate, no ink enters the new vessels, but rushes into those in the old wood just beneath. This ready injection of the old wood in the spring can be shown to be a characteristic the old wood develops only as the new vessels differentiate over its surface.

We must now recall that this vessel differentiation is initiated in the new wood in connexion with vessel differentiation in the young buds above. Again, all vessels in the axis of a bud are differentiating in connexion with some expanding leaf within the bud, and it follows that, interrupted at most by one or two unperforated cross walls, these vessels are continued now, in ring porous types, right to the base of the trunk as a continuous series of perforated segments which are expanding under the pressure of their liquid contents. Evidently there is in this system a source of water supply to the growing shoot, a supply which is not directly dependent upon any active process of supply from the root, provided always that root activity has brought about the absorption of the water which has gradually filled up the old wood during the winter months. The actual conditions under which the water is delivered to the bud have still to be elucidated, the only point which is clear as yet is that the supply is controlled by the living protoplasm during the early stage of growth.

The young expanding vessel still contains living contents which undoubtedly play a part in the subsequent stages of wall thickening and lignification, and throughout these stages there are present in the vessel as many separate protoplasts as there were original cells to form the vessel-segments. This point cannot be demonstrated in the strips, because the process of removal of the strip squeezes and disorganizes the contents of the delicate expanding cells of the young vessel. Certain precautions described elsewhere (8) have to be taken to demonstrate these protoplasts, but it is possible to show that right up to the

stage of complete lignification the vessel is filled with a file of living protoplasts. These are no longer separated from each other by cellulose cross walls, although a gelatinous film of pectin continues to separate them for some time. It is the contents retained by these semi-permeable protoplasts which provide the osmotic force to absorb the water from the old wood and to drive outward the wall of the new vessel, until the counter pressure of the surrounding tissues prevents further expansion. So long as the liquid contents of the vessel are thus retained within the long file of protoplasmic sacs, the rate of delivery of water to the leaf above, with which the vessel is in direct communication, will be slow, but clearly with increasing age these protoplasmic membranes will gradually lose their property of semi-permeability. There must come a time when the protoplasm no longer restricts the movement of the sap in the file of protoplasts, when their contents must coalesce into one long liquid column. This liquid is certainly drawn upon, either by the leaf above or by the newer vessels which are differentiating nearer the cambium, because shortly after the vessel is fully lignified, injection experiments show that its contents are no longer under pressure. In fact the probability is that the vessels at this stage contain only water vapour and a little air at a pressure very much less than atmospheric (6).

Vessel differentiation has thus proved to be a mechanism, inherent in the process of radial growth in the hardwood tree, which must have vital significance for the movement of water into the growing shoot. These observations challenge many theories as to the mechanism of sap ascent in the tree. They have been discussed to some extent from this standpoint (6), but they are still too incomplete to permit of a full examination of the problem even from this particular point of view. When regarded with the interests of the forester in mind, one point seems to deserve emphasis. This mechanism of vessel development and the associated effect upon water movement, in ring porous trees particularly, must be active especially in the spring. In diffuse porous trees with their slower basipetal vessel differentiation, the effect may be longer in evidence though still in the earlier part of the growing season. Since the water impelled by the system of growth and differentiation is presumably being driven into growing shoots, the amount of extension growth in a shoot may well be closely connected with the differentiating vessel-systems which are in longitudinal connexion with this shoot.

We may examine from this standpoint some well-known 'ringing' experiments of O. F. Curtis and the conclusions that he draws from them (1). Early in the season Curtis ringed twigs of *Crataegus* and other plants through the outer bark and phloem, and subsequently studied the growth of the twigs above the ring. Where the amount of shoot and number of leaves left above the ring is considerable, the extension growth of the shoot above the ring is greater than when little shoot is thus left isolated above the ring. As the leaves left above such rings do not flag, Curtis concludes that the relative failure in growth above the ring is not due to lack of water but to lack of nutrient material for growth which should normally have moved forward in the phloem.

But a ring which interrupts the phloem also stops the basipetal impulse to new growth in the cambium, and thus prevents the vessel differentiation, which is proceeding in continuity with the leaves developing on the shoot above the ring, from extending farther down the shoot than the ring. In this way a mechanism which collects and supplies sap under pressure to a growing shoot, and which usually has an almost indefinite extension down the shoot, is limited as regards its extent and as regards the area from which it may derive water for supply to the growing parts above the ring. There can be no doubt, therefore, that such rings do in fact much restrict the supply of water and solutes to the growing shoot, which is normally provided for by the full extent of the basipetally differentiating systems which are initiated in the bud and spread from thence down the tree with the resumption of radial growth.

From the same standpoint many effects of pruning and of normal bud development, which are associated with the competition between buds, may be elucidated.

In many trees, as for instance in the apple, the topmost buds of a vigorous shoot start growth first and their growth seems to repress the growth of buds lower down the shoot, which produce little extension growth and some of which remain dormant. To explain such results, the intervention of hormones, or even growth-retarding substances or chalones, has been far too readily assumed without adequate consideration of this growth system, which is linked with the growing buds above, but which is differentiating downwards over the surface of the old wood. In such an apple twig, as the distal buds have started growth first, vessel-systems communicating with the leaves in these buds are already differentiating down over the surface of the old wood and around the insertions of the lower buds before the latter have started to grow. These vessel systems will withdraw water from the old wood which would otherwise have naturally found its way into these lower buds. Small wonder, therefore, that their growth is less vigorous or that they even fail to grow at all, unless the growing buds above them are removed or are killed by frost, when the water accumulating from the root-system is once more available for them, and they grow out.

THE ADULT LEAF AND RADIAL GROWTH.

The observations so far recorded have shown the intimate connexion which exists between the growing extension shoot and the radial growth on the axis below it. Radial growth persists, however, on the trunk after extension growth appears to have ceased in the leafy canopy above, and the relation of the vascular system of the adult leaf to the axis obviously needs examination. Such an adult leaf has ceased to expand in size, but it is still active as a photosynthetic mechanism. The food manufactured in excess of its own small requirements, now that it is no longer growing, must be made available for the tree. Otherwise, forestry would be a non-existent occupation, because the food made by the adult leaf must be the material stored in the timber of the tree.

The processes of the vascular growth in the leaf have been under examination by J. H. Elliott (2), and the results again have been somewhat surprising.

So long as a leaf is growing, growth continues in the vascular- or vein-systems, and new elements are added to the wood by the differentiation of cells cut off from the cambium.

But when leaf expansion ceases, wood formation ceases also, and neither in the veins in the leaf nor in the upper part of the leaf trace (the name given to the continuation of the vein-system of the leaf into the stem) are further elements added to the wood, although a few isolated elements may continue to be formed at the leaf base or leaf insertion. Thus when the leaf is adult, it ceases to contribute directly any further wood elements to the stem upon which it grows. If then new elements are still being formed by radial growth in branches and trunk, are they without connexion with the vascular systems in the leafy canopy above? To answer this question has proved very difficult; it has been under examination in various ways, and the results of many series of observations have still to be summarized for publication. Briefly it may be stated that the wood elements which form during the summer months always appear to be associated with growth activity proceeding at the shoot apices above. In some instances, leaves are still growing nearer the apex; in all cases, buds are differentiating and the scale leaves and young leaf primordia in these buds are linked through the bud axis with the vascular systems which are still forming during the continued growth on the tree axis.

The appearance of the leaf trace of an adult leaf, immediately after its entry into the stem, either in a herbaceous or woody stem, is a complete and conclusive demonstration of the fact that no further wood has been added to the stem by the continued differentiation of wood downwards from the adult leaf. The wood of the leaf trace in this region below the leaf insertion does not alter in appearance at all from the moment that the leaf is adult until it falls, and this appears to be true even when, as in the evergreen hardwoods, the leaf remains on the tree through several growing seasons. In the leaves of some evergreen species there may be a little more wood added in the second year in the main vein of the leaf, although the cambium soon ceases to be active on the wood side, but in all cases examined so far there is no evidence that in the hardwood such additional wood differentiates down along the trace to contribute to the formation of wood elements upon the main axis of the tree. On the other hand, the adult leaf does continue to be associated with the further development of phloem. In some cases the cambium in the main vein is more active after the leaf is adult than before, but all the new elements are now being added to the phloem side. This phloem differentiation in the leaf in sycamore coincides with a vigorous basipetal impetus to phloem development right down the branches and trunk (3). These facts are certainly true for sycamore, where phloem development has been followed throughout the season by J. H. Elliott, but it is unsafe to generalize from the data gained on this single species. Further evidence on this point will only be accumulated slowly as the strip method cannot be used so well for this purpose, although after xylem formation has ceased beautiful preparations of differentiating sieve-tubes may often be obtained by making 'strips' from the inner face of the bark.

Phloem differentiation now needs the same intensive study as vessel differentiation in the wood is at present receiving.

A point that needs emphasis is the vigour of the phloem production. Basipetal radial growth on this scale means also a vigorous transference of food material downwards on the trunk from the leaves where it is manufactured to the regions of the tree where it is stored. As tissue differentiation proceeds in this rapidly forming phloem, the first stage of growth and food accumulation is followed by a stage of differentiation and dispersal of these accumulations. The substances piled in the sieve-tubes during their growth are then released. Some appear to move laterally and find their way across the cambium to the slowly differentiating summer wood on the other side. Here the sugars, &c., released from the differentiating phloem, are being stored in the form of thickened walls of the summer wood elements and as other storage products. Towards the end of the growing season the tissues formed on the phloem side do not expand much nor do they fully differentiate. Their differentiation is probably retarded owing to water deficiency at that time.

At this point growth ceases, the cambium passes into an inactive state, and the cycle of radial growth is completed. During the winter, water accumulates again in the old wood by processes which are very little understood. Large quantities of water obviously cannot accumulate in the tracheae by the release of tensions on liquid columns, in which even enormous tensions produce but little change in volume. Nor can this be explained by the growth systems which are in operation in the spring. No problem in the whole gamut of those connected with sap ascent seems to call more urgently for re-examination than this slow filling with water of the wood throughout the tree. No phenomenon is more fully attested by the observations of the scientific forester and the experience of the practical man. In England this filling up process is well advanced by the spring until, aided by the expansion due to the advent of warmer temperatures, the water reaches the relatively undifferentiated tissues outside the cambium. Here, the partially differentiated phloem tissues, which were unable to complete their expansion at the end of the summer growing season owing to water deficiency, now begin to swell with the water, expand, and resume their process of differentiation.

This resumption of phloem differentiation early in the spring may perhaps throw some light upon one of the problems left for solution in the ring porous trees. Why does radial growth, when it is resumed in the buds in the spring, spread so rapidly down the tree? The phloem of all these ring porous trees is characterized by large sieve-tubes with a relatively wide meshwork on the perforated sieve-plate. This is especially marked in the simple sieve-plates of ash and common elm, but is also quite striking in the compound plates of sweet chestnut, oak, and wych elm, and the simple plates of the rather smaller tubes of laburnum. Perhaps we have to look to this phloem system, which commences to swell and differentiate before the cambium commences activity again, to find the system which renders possible the extremely rapid spread down the tree of the renewed impetus to growth. The differentiation of this

phloem may very possibly provide, by the rapid release of nutrient materials from the wide sieve-tubes, the supplies of food which must be readily available for the new growth to proceed.

Here we are passing beyond facts to speculation. This brief incursion into speculation may, however, justify the note on which the introductory statement to this paper finished. We find in the radial growth and subsequent activity of the phloem a process, the initiation of which seems clearly to be associated with the adult leaf. The supplies from the adult leaves must in this way influence profoundly the radial growth processes proceeding on the trunk. There is even the hint that the nature of the radial growth processes thus initiated in the phloem (for example the type of sieve-tube) may determine the rate and manner in which cambial activity and formation of new wood is resumed in the spring, although this resumption of cambial activity is, at first sight, directly connected only with the newly expanding buds.

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THE FATE OF RESERVE MATERIALS IN THE FELLED TREE[1]

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INTRODUCTION.

THE reserve materials of a tree are stored in the living cells of the wood. In a young stem these cells constitute the medullary rays, the longitudinal parenchyma whenever present, and the pith. In an older stem where the central region, the heartwood, is dead, the outer zone, the sapwood, alone serves for storage and for water transport. The traffic details of the living sapwood have not yet been fully made out, but, so far as we know, the only functions of the living cells, as contrasted with the vascular and fibrous elements, are to receive reserve materials arriving from the leaves, to hold them in store until required, and then to hand them on to neighbouring tissues for transport. That such reserves often comprise a large mass of material in a deciduous tree is evidenced by the crop of foliage which is suddenly produced each spring. The reserve requirements of evergreens may not be so great.

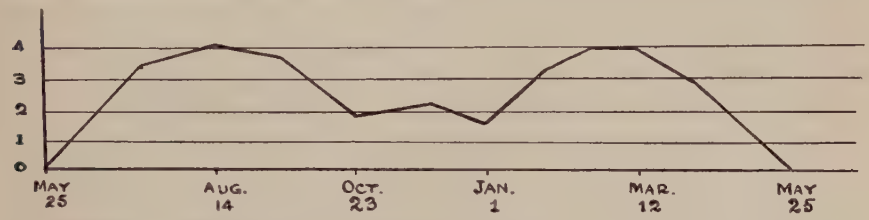
The reserve materials in trees are chiefly starch, sugar, and fat. It will be readily appreciated that if such eminently edible substances are still present to an appreciable extent in the wood when it comes into service as timber, we can expect invasion and damage by organisms which are capable of using such reserve materials as food. The well-known liability of sapwood to damage by insects and fungi, and its rejection in consequence, means considerable loss. In oak, for example, only heartwood is used for better-class work, the sapwood being discarded. In other timbers such as walnut the sapwood constitutes too great a proportion of the tree to be discarded as a rule, and it is often artificially darkened to resemble heartwood; its durability is not thereby increased however. In ash the sapwood is the more valuable part of the timber, and the best quality ash, from young trees, is all sapwood. The indurability of sapwood is a world-wide characteristic, and it follows that great economies would follow the rendering of sapwood immune from invasion by common fungal and insect pests, unless such immunity were obtained at too great expense.

RESERVE MATERIALS.

Of the reserve materials, starch is the one which is most easily identified, and is of commonest occurrence. The dark blue (in effect black) colour given to the grains of starch by an iodine-potassium iodide solution is seen with the naked eye when starch is plentiful and the sapwood of light colour. The use of a lens

[1] A paper read before a joint meeting of the Botany and Forestry Sections, British Association for the Advancement of Science, Norwich meeting, Sept. 1935.

is necessary where the sapwood is a naturally darker colour, and for small amounts of starch, microscopic sections are advisable. The radial section or face is preferable, as the rays are displayed in their broad dimensions. The amount of starch present can thus be estimated and graded according to a colorimetric scale of one's own (1). This method was used by Cockerham (3) in his study of the variation in starch content in the several regions of the sycamore tree (twig, stem, and root) during the year. Text-fig. 1 shows his results for the trunk of the tree. He recorded starch in four grades, represented by the horizontal lines, and the curve shows the filling of the sapwood storage cells during summer to a maximum in August. The winter fall is probably to be explained by



Text-fig. 1. Seasonal variation of starch in 20-year sycamore (trunk region). (After Cockerham.)

the conversion of some starch to sugar in cold weather, for the same maximum is recorded for spring. From this spring maximum there is a sudden fall, due to heavy withdrawals as the foliage forms, thus completing the annual cycle. The other regions of the tree showed comparable changes in quantity, but the more distal roots retained a considerable amount when other regions held little. The annual cycle of events in the storage cells is illustrated by this curve, and is as follows. In summer, when the leaves are manufacturing more carbohydrate than is immediately required, the excess travels as sugar to the sapwood storage cells in stem and root. Here it is laid down in reserve, and may be converted to starch or fat. Thus by the time of leaf-fall, the storage tissues are fully charged. In cold weather, starch may be replaced by sugar for a time, but the total reserves in any one region are probably not appreciably altered until the time of rapid diminution in spring, when, travelling again as sugar, the reserves are withdrawn from storage to be used as building materials. No doubt nitrogenous and other reserve substances follow a similar cycle. The heavy drain on the reserves in spring does not, as a rule, completely empty the storage tissue, because there is retained, somewhere, a sufficient amount to produce a second crop of leaves should the first be destroyed: but there is insufficient for a third crop, so that a tree cannot recover after defoliation twice in quick succession as may happen when frost damage is followed by the attacks of caterpillars. The last reserves seem to be held mainly in the roots. It is rare, however, for the sapwood of the trunk of a tree to be completely denuded of reserves, although Cockerham found that condition in sycamore. Among hardwoods, oak, ash, elm, walnut, and many others have reserves in the form of starch. Some, however, such as willow and birch, have mainly fat, while the common conifers appear to have both starch and fat together.

Starch studies serve to show the great variableness of reserve materials in wood. For instance, there has been described in those trees which have well-marked seed years at long intervals (e.g. beech) a corresponding cycle of variation in reserve materials. There are also radial and tangential variations in the same region of a tree. The younger the sapwood, for example, the more active is the work of storage and withdrawal, possibly because of a better oxygen supply through the bark. Reserves, then, vary from species to species as to the kind of material stored; and in quantity, from tree to tree, from region to region within the tree, from year to year, and, most important, from season to season round the year in all trees, and particularly in deciduous kinds.

DEPLETION OF RESERVE MATERIALS AFTER FELLING.

In this country trees are mostly felled in winter, at which season reserve materials are present in maximum amount. There is nothing in the felling of a tree to occasion the immediate death of the sapwood cells except at exposed surfaces. Evidence of the continued life of sapwood is frequently seen in such trees as willow and poplar, which often send up leafy shoots from beneath the bark of the trunk as it lies on the ground, of the same nature as stool shoots, which are commoner still. But, lacking attachment to the soil, the trunk shoots, unlike the stool shoots, do not long survive, because they soon exhaust the available reserve materials and water supply. Apart from localized shoot production, however (that is, irrespective of any further growth whatever), there would appear to be no reason why sapwood cells should not continue to live as long as their individual reserve materials last, provided no lethal factor comes into operation; and such continued life must result in the gradual depletion of the reserves to exhaustion. Briefly stated, therefore, if we can provide conditions wherein the sapwood cells continue alive, starch-free timber will ultimately result, no matter what quantity was present at felling. These conditions are supplied by keeping the log 'in the round', with the bark on, and the ends and bare places covered over with some substance such as limewash or paint in order to delay drying out. The time required for this process varies with each individual log, according to its initial starch content and the width (depth) of the sapwood; the time required is also affected by the weather conditions, since temperature affects the rate of activity of the cells. On the other hand, lethal factors begin to operate as soon as the log is broken up or 'converted', and they may operate throughout the whole of the wood or only partially, according to the dimensions of the products of conversion and to the subsequent treatment. The usual lethal factors in commercial practice are desiccation (drying at surfaces or throughout the whole of the piece) and heating by kiln treatment, to the death-point of cell protoplasm. However occasioned, the death of a storage cell results in the retention of the reserve materials then present within it, and there is no way yet discovered (nor seems likely) to remove starch, for example, short of reducing the wood to powder and extracting with boiling water or other solvent. This latter method has been used by Campbell (2) for

isolating wood starch from oak and walnut in order to examine its chemical and physical properties.

It should be mentioned here that, after the process of depletion of cell reserves has come to a natural end, there are to be found scattered irregularly in the sapwood a few cells containing starch grains intact. The cells occur singly, or at most a few together, and they cannot be induced to resorb their starch. It seems certain that these cells died before depletion commenced, possibly in the standing tree. For all practical purposes this minute amount of retained starch is negligible. Their occurrence is puzzling, however, and is of interest as offering a possible explanation of the recorded occurrence of starch-containing cells in heartwood (since the process of heartwood formation would not affect them). Only the living protoplasts can remove starch grains from inside a block of wood.

It is, of course, essential that there be complete removal of the sapwood starch (disregarding only the scattered cells just mentioned) *before the log is converted*, because otherwise difficulties arise over the location of any starch that may ultimately remain in the products of conversion, whether baulk, or plank, or dimension stock direct-sawn or re-sawn.

The difficulty arises from the fact that in such circumstances (conversion before depletion), there may be some resorption of starch within a conversion product subsequent to conversion, so that the iodine test, necessarily applied at surfaces, does not indicate the amount of starch below such surfaces (9). This condition is just what does in fact often arise in sawmill practice. Generally logs are at a stage of partial depletion when broken up, and the pieces then show various initial starch-gradients. These gradients are further modified by subsequent starch resorption during seasoning, so that the final breaking-up of the piece yields blocks having very varied and complex starch distributions. Thus the iodine test, simple and easy as it is for showing the occurrence and depletion of starch in the log, is too difficult for any one but an expert to use on timber which is *not* cleared of starch before conversion.

The 'log-seasoning' method of producing starch-free sapwood is attended by certain risks, the chief of which is that of fungal attack during the period required for depletion. To minimize this risk it is necessary to take some care with the logs. To leave the felled trees on the ground in the warm, humid conditions of a woodland in summer is to invite trouble. They should be piled off the ground in the open, or, better still, under cover. The depletion progress is followed in sample logs by periodic tests for starch, especially at the inner or deeper zone of the widest sapwood region of the particular log.

Adopting these or similar precautions, the method is found to be practicable in the case of hardwoods which have relatively narrow sapwood, including oak, elm, and sweet chestnut. Winter-felled timber of these species will generally be found to be devoid of starch by the following autumn. Willow, having the narrowest starch zone of all, requires the shortest time, in some instances only a few weeks. Trees with wide sapwood, including ash and walnut, may require a whole year or longer before the last of the starch disappears; these should

always be stored under cover, in an open shed. Timber which quickly discolours when kept in the round, for example sycamore and beech (which have no distinct heartwood), must not, however, be subjected to the 'log-seasoning' treatment, but must be converted as quickly as possible after felling, especially in mild weather. No observations have yet been recorded on resorption of reserve materials in coniferous timbers after felling.

The same process of starch depletion goes on in logs submerged in water, and though this treatment is generally quite impracticable in this country, it has been suggested with some reason that in tropical lands submergence might serve the useful purpose of preventing the infestation of logs by pin-hole borers and other forest beetles which frequently attack timber immediately it is felled. Many difficulties of this sort arise when attempts are made to apply the results of laboratory experiments to field practice.

LYCTUS AND RESERVE MATERIALS.

Widespread interest in reserve materials has spread among timber technologists since the discovery, or rather the re-discovery, of the fact that the *Lyctus* powder-post beetle is dependent on wood-starch for its food (9). At the end of the last century Mer found that what is known as 'the worm' only infests wood when starch is present, and he experimented with methods of depriving wood of its starch with considerable success. His methods were never, so far as one can discover, adopted in practice, and the published accounts of the investigations have been lost sight of until quite recently.

Lyctus has received a good deal of attention in recent years, and I need only refer here, for the sake of those who have not made its acquaintance, to the main features of its attack. It is the grub (larva) of the *Lyctus* beetle which tunnels in the sapwood. It eats its way through the wood, and the tunnels are found packed with fine wood dust, which is faecal matter. A heavy or a lengthy infestation results in the complete reduction of the sapwood to powder, except for a thin shell of surface wood left intact until the adult beetle eats its way to the open air. The exit holes are often the first sign of damage. It has been pointed out by Mansour (5) that wood-boring insects deriving their nutriment from included carbohydrates must ingest relatively huge quantities of their food material in order to extract sufficient digestible substance for their growth, and he compares the *Lyctus* larva with the earthworm in this respect. Hence we find large accumulations of frass as excreta from such larvae, and correspondingly serious damage to the wood infested.

Although starch is not the sole food of the *Lyctus* larva it is the main food substance, and among the numerous species of tree whose sapwood is liable to infestation by the powder-post beetles, the amount of starch present is the measure of the nutritional value of the wood for *Lyctus*. Other qualities of sapwoods affect the incidence of attack. For instance, the pore size, or vessel diameter, in relation to the size of the egg and ovipositor of the beetle, may be a limiting factor. The pore-size theory states that unless at least some of the

pores are big enough to admit the ovipositor of *Lyctus*, the wood is immune no matter what its 'nutritional value'. This theory rests on observations and careful measurements of sizes of pores, ovipositors, and eggs, but is not as yet supported by adequate experimental evidence. The kind of proof called for would be to induce infestation in an otherwise non-infestable timber by artificially providing 'pores' of a larger diameter, as by widening existing pores with a needle and offering the sample to the adult beetles. Further, there seems no doubt of the beetle's ability to oviposit in small cracks or fissures, thus successfully infesting timbers having no pores large enough to admit the ovipositor (7).

Later studies by Parkin (unpublished) have demonstrated the occurrence of a water-soluble substance, in the absence of which normal larval growth is prevented, though abundant starch be present. This new fact may assist in the immunization of timber by the submersion method. As, however, many of our common hardwoods have large pores and contain starch, and as immersion in water is impracticable, the reduction of damage to timber by powder-post beetles in this country is not to be effected by considerations of vessel diameter or of water-soluble sapwood extracts, important though these may be as extensions of our knowledge of the biology of wood-tunnelling insects. A certain proportion of the stocks of 'infestable' species of timber is found by examination to be immune because starch-free, and this condition arises incidentally (by log-seasoning) in the ordinary course of commercial practice. It is, therefore, submitted that the only sensible plan to adopt is to extend the application of the process to as much timber as possible. We have to teach people to handle their timber intelligently; it is surely not too much to expect those in the timber industry to know a little about the reserve materials in sapwood and their fate in the felled tree.

It is to be regretted that in recent technological literature the term 'seasoning' has been not only assumed but stated to be synonymous with the word 'drying', and that the term 'kiln-seasoning' has come into use. We now know a good deal more about the changes that take place in timber with the lapse of time, although there is much still to be discovered. The little-known changes in wood referred to as 'ageing', for instance, must in the nature of things commence from the felling date. True seasoning is in some instances carried out under water, and although, as a rule, seasoning does involve drying, the word conveys, and should convey, a much wider meaning. 'Kiln-seasoning' is, I submit, a misnomer; the term should surely be 'kiln-drying'.

I may call attention here to the possibility of relating the very marked spread of *Lyctus* in recent times to the extension of the practice of kiln-drying. Beetles of this family now cause more financial loss in this country than all other insect pests of timber taken together, not even excepting the notorious Death-watch beetle. There can be no doubt that the conversion of hardwoods more quickly after felling, whether associated with kiln-drying or not, is a modern change which greatly favours *Lyctus*. It is understood, however, that seasoning experts are now reverting to the view that it is best to postpone kiln treatment

until the timber is partially dried by slower means. Thus 'seasoning', in the true sense, is coming back into favour.

In those instances where the log-seasoning method of immunization is not practicable, the possibility of keeping *Lyctus* in check by means of other treatment may be considered. Heat treatment, for the purpose of killing off living eggs and larvae already in the wood, serves to sterilize the timber without, however, conferring any immunity; it may become infested again immediately afterwards. The method has definite limitations, being applicable to relatively small pieces as it involves kiln treatment. The impregnation of sapwood with fluids having deterrent or insecticidal qualities is engaging attention. Apart from technical and practical difficulties attending such methods as these, there is the serious matter of the cost of the treatment. In passing, it may be noted that the log-seasoning method provides the simplest way of allocating legal responsibility for *Lyctus* damage when claims arise or disputes occur between saw-millers and manufacturers. If the saw-millers undertake to supply *starch-free* timber, and their failure to do so results in *Lyctus* infestation, the responsibility would be theirs, no matter at what later stage the damage was discovered.

DETERMINATION OF THE QUANTITY OF RESERVE MATERIALS.

Ascertainment of the amount of reserve materials of different kinds occurring in sapwood, living or dead, is difficult. The matter is not only of general botanical interest, in the study of the economy of the growing tree, but is important to research workers investigating the relationships between invading organisms and the wood they inhabit. An attempt to determine the total reserves in selected samples of sapwood will now be described.

The method is to find the loss in dry weight of the sapwood during the depletion process, and it assumes that all reserves are resorbed before the cells die. It may be called the *specific gravity method*. The specific gravity of a piece of wood is arrived at by finding the volume of the sample when it is saturated with water (that is the condition in which wood occurs in the living tree, and it can be reproduced from the dry state by soaking); then the dry weight is found by drying the piece in an air oven at just over the boiling-point of water until a steady weight is obtained. Such dry weight, divided by the (saturated) volume, gives the specific gravity as usually reckoned for wood. In our experiment we cannot use the same piece of wood for specific gravity determination both before and after depletion, so we have to use matched samples, such as are provided by taking adjoining blocks from a stem or branch. A piece about 2 inches in diameter and a foot long is cut in winter; in such a piece all the wood is sapwood, and, judging by starch tests, the reserve substances are uniformly distributed. From the piece, short blocks (disks) are cut from each end, leaving a middle piece about 6 inches long. The disks are dried quickly in air, while the middle piece is put aside with ends sealed, for depletion. The end of the depletion process (which is coincident with the cessation of respiration) is found by the gas analysis method (9) and the middle piece is then also cut into disks. We now have both depleted and undepleted blocks, from the

same short length of stem, and the specific gravity of these is found as described. A test of the method proved it to be sufficiently accurate to give identical values, to the second (sometimes third) decimal place, for adjoining blocks of one kind. The results may be summarized as follows: oak branch wood was lighter after depletion by 2·1 per cent.; sycamore by 3·5 per cent. and 4·7 per cent. respectively for two different branches; ash (stem of sapling) by 2·4 per cent.; and horse-chestnut (sapling) by as much as 6·7 per cent. These figures apply to the particular samples only, and must not be given wider application. They are, however, of the same order as the results obtained by Campbell (2) for the quantity of starch in selected pieces of oak sapwood.

In these experimental samples the initial requirement that all reserves should have been cleared from the sapwood cells was satisfied (so far as could be discovered), but it was realized that the loss in dry weight could only be an accurate figure for the total respirable cell-contents provided there was nothing in the cell-cavity at the end that was not there at the beginning, and nothing added to the cell-walls either structurally or as impregnations. S. H. Clarke, of the Forest Products Research Laboratory, kindly made measurements of the cell-walls of these storage cells before and after depletion, and he found no difference. There are no signs of cell-wall impregnations; but, unfortunately for the value of the method, *the cells are not empty* after the reserves have disappeared. There is a new substance there, an amorphous mass, brown or yellow in colour, partly filling the cavities of the depleted cells to an extent that cannot be regarded as negligible.

The amorphous substance is insoluble in water (cold or boiling), in alcohol, ether, acetone, saliva, &c. It is not coloured by iodine, but turns grey or black with iron salts, indicating the presence of tannin. It is darker and more plentiful in oak and alder than in ash or sycamore, but in all depleted sapwoods it is present in sufficient amount to darken the colour perceptively, compared with the corresponding undepleted samples.

Thus the 'loss in dry weight' figures, considered as indicating the amount of reserve materials resorbed, are too low, and require correction for the weight of the new substance. Its insolubility does not, however, promise easy determination.

This new substance presents marked resemblances to the so-called *heart substance* of 'heartwood' trees. It may be that the sapwood cells, dying prematurely of exhaustion, behave as they are destined to behave in the living tree when their time comes to take part in the process of heartwood formation. If this be so, the phenomenon may throw some light on that little understood process. It would appear that our sapwood is not only depleted of its reserve materials but is partially converted to heartwood, thereby sharing its vastly different technical qualities.

FURTHER PROBLEMS.

This paper will be concluded with a brief reference to extensions of these researches which await, or are receiving, attention.

More complete information about the reserve materials in growing trees is urgently required; e.g. their chemical nature, their ebb and flow in the sapwood, the effect of seasonal influences, and their exact location and quantities in different trees and in the various tissues of the wood. Such information is not only of general botanical interest but would be of great value to foresters experimenting with silvicultural methods, and to timber technologists working on chemical, physical, and biological problems aiming at the better utilization of the timber product of the trees. Pomologists have recorded some valuable observations on branches of fruit trees (8), and Cockerham (3) has studied whole sycamore trees of commercial size, throughout the year. Work on these lines is now proceeding in Australia (4), but so far as is known nothing is being done in relation to our native trees. The conifers appear to have received little attention, apart from the study of their twigs and small branches. It is certain that a comparison between a deciduous conifer, e.g. larch, and an evergreen pine would provide valuable facts. Thus a wide and promising field presents itself to the forest botanist.

Only passing reference can be made to the mycological aspect of the occurrence of reserve materials in sapwood. It has long been known that moulds such as *Ceratostomella* feed on the carbohydrates included in pine sapwood, and recently a start has been made on the study of other sap-stain fungi (9). I suggest that there is a distinct possibility, of interest to forest pathologists, that the study of sapwood reserves would throw light on the nature and incidence of certain tree diseases which have recently come into prominence in this country.

The whole subject of the digestion of wood by insects is receiving attention (4) (5) (6) and information is being gathered on the bionomics of the *Lyctidae* in particular (7).

Many organisms invading trees and timber, besides those already referred to here, must be concerned with stored reserves in sapwood. Most of them make their initial attack on the sapwood, and it is worth while discovering to what extent they are dependent on, or aided by, the cell contents present there.

For the biochemist there is much scope for extending our knowledge of the differences between sapwood, heartwood, and those indefinite zones and conditions occurring in trees such as sycamore, beech, and many others. A great deal of the published work on the chemistry of wood omits to state which zone it is that is under examination. Modern workers are remedying this serious deficiency to some extent (2) and it is hoped that, as a result, the physical and mechanical aspects of the subject will receive attention in due course now that the biologists have pointed out the road.

SUMMARY.

Forest trees are usually felled in the season (winter) when the sapwood contains abundant reserve food-materials. These, as starch, sugar, fats, &c., occur within the living storage cells which constitute the medullary rays and the wood parenchyma. The fate of the reserve materials is now shown to depend

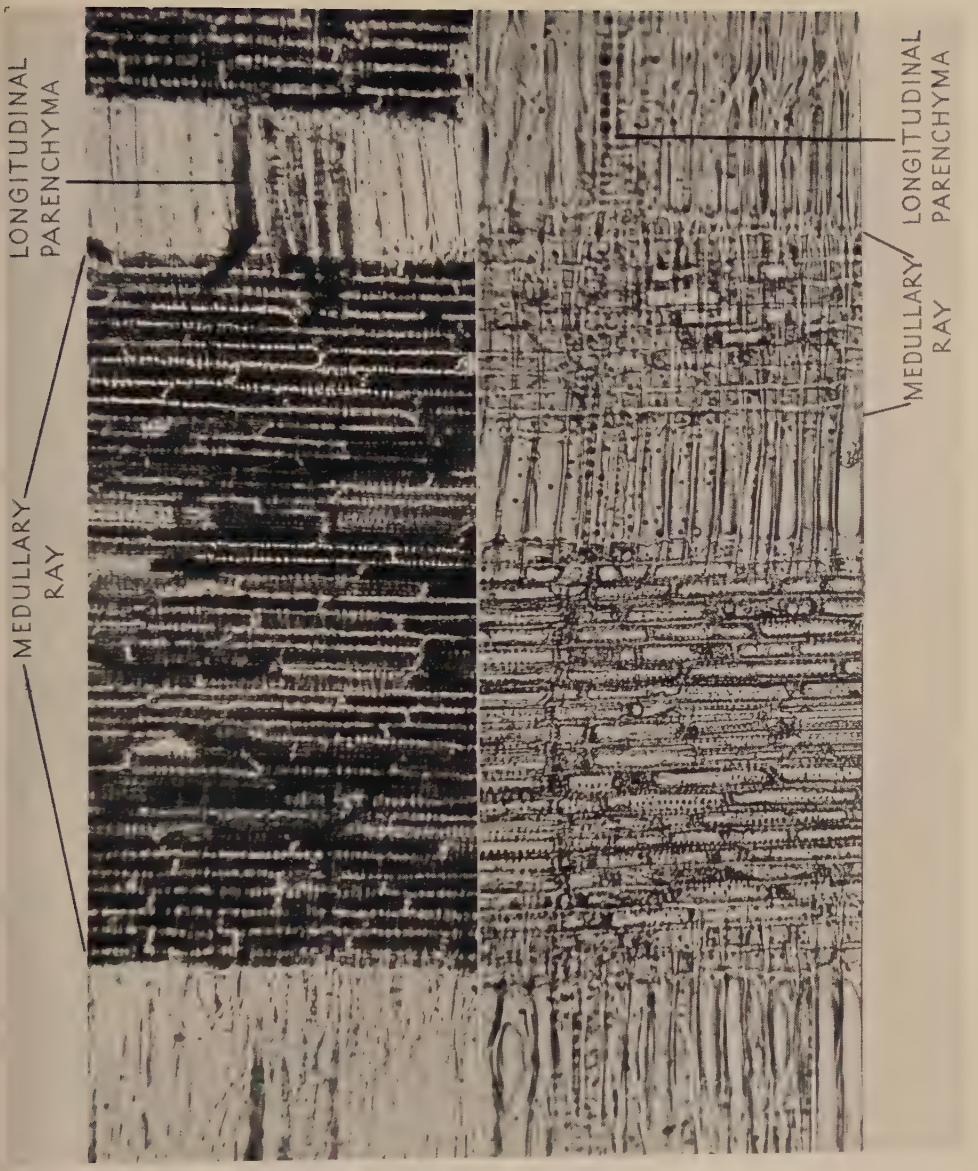
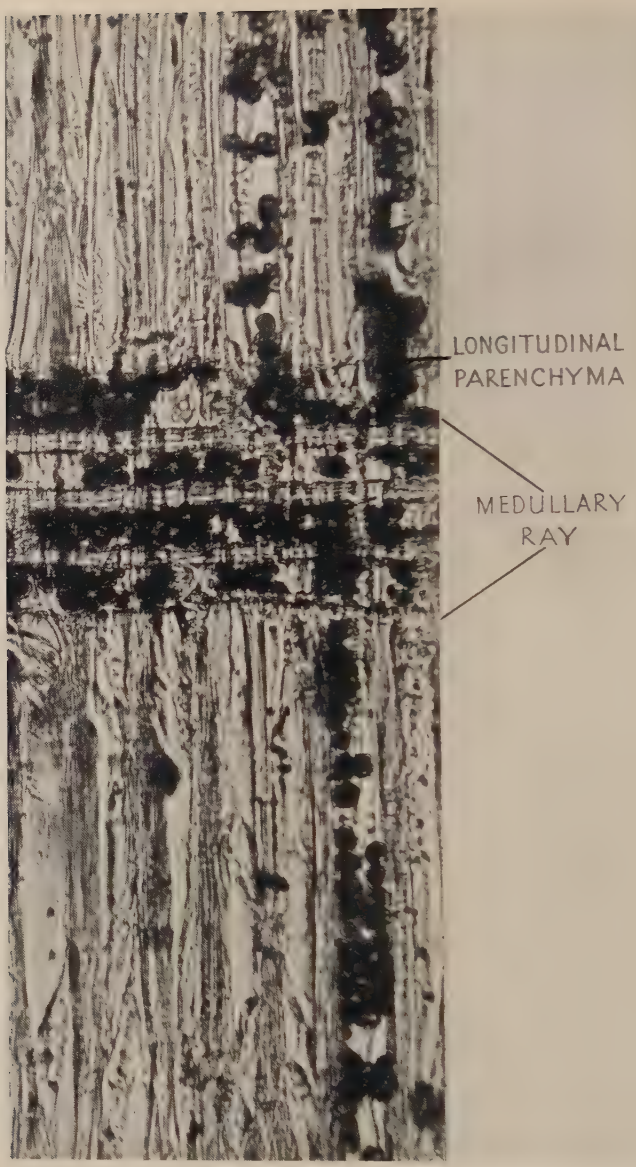


FIG. 1. Photomicrograph of thin radial section of sycamore sapwood, as at felling. Treated with iodine : starch shown black. × 200

FIG. 2. The same after depletion Starch absent. × 200

Photomicrograph by the Forest Products Research Laboratory

PLATE IX



The same as Plate IX, more highly magnified, showing individual starch grains. × 535

Photomicrograph by the Forest Products Research Laboratory

PLATE X

on the treatment of the timber after felling. If the log is kept whole, and the bark retained to prevent rapid drying, the storage cells continue alive until all reserves are exhausted; whereas if the timber is converted quickly, and the cells killed by desiccation or kiln-heat, the reserve materials remain intact and cannot thereafter be removed by any known treatment.

Timber containing reserve materials is shown to be a ready prey to wood-tunnelling beetles and sap-staining fungi. In particular, *Lyctus* powder-post beetle larvae feed on the starch occurring in oak, ash, elm, walnut, &c., so that removal of the starch by the 'log-seasoning' process serves to immunize the timber against *Lyctus* infestation.

A gravimetric method of determining the total amount of respirable cell-contents in experimental samples is discussed, and the further bearings of the occurrence of reserve materials on technological research are outlined.

Suggestions are put forward for the co-operation of forest botanists with timber technologists in extending our knowledge of these important reserve materials, with a view to the better utilization of our native timber trees.

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PORTCLAIR

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INTRODUCTORY.

PORTCLAIR Forest is one of the properties acquired by the Forestry Commission in the great glen which runs across Inverness-shire from north-east to south-west. It is part of the old natural birch–pine–oak forest which extended from the eastern fringe of Kintail along the banks of Loch Cluny and the Moriston River and which continued along the north margin of Loch Ness. In Portclair there are still small patches of natural pine remaining on the fringe of the Commission's plantations, and a few natural pines are scattered throughout the western end of the forest: the areas of natural pine are much more extensive in Inverwick Forest, but they die out in small patches of very stunted trees to the west of Inverwick Forest. The name Portclair is shown on the map of the district published by Robertson in his *General View of Agriculture in the County of Inverness*, published in 1808, but the name was in use apparently as early as the fifteenth century. Robertson in his account of the woods of Glenmoriston draws attention to the greater quantity of pines to be seen on the north-facing slope, and to the predominance of birch on the south-facing slope: the observation appears to have been accurate. Robertson gives a rather depressing account of the conditions of the oak woods, but he is much impressed by the extent and quality of the birch and pine woods. Telford's map, published in connexion with the construction of the Caledonian Canal, states that 'there is a great quantity of fir timber in Glenmoriston'. The statistical accounts of 1798 and 1845 give short accounts of the Glenmoriston woods and of the exports from those woods. Dr. Mackay in his *Urquhart and Glenmoriston* suggests that it is probable that the 'wonderful ship' built at Inverness in 1249 for the Earl of St. Pol and Blois for an expedition to the Holy Land was built with pine from Glenmoriston and oak from Glenurquhart, but he does not give his reasons or evidence. Glenmoriston in the seventeenth century supplied timber for the repair of Fortrose Cathedral, and for the re-erection of the Inverness wooden bridge. Further evidence of the early trade in Glenmoriston timber is supplied by a letter of inhibition issued by the Crown (1573), and by the order issued by the sheriff of Inverness-shire 1563. The neighbours and tenants of Glenmoriston had broad views on property rights in timber, bark, game, and pasture. The royal inhibition by James VI provided for the proclamation of the names of offenders against forest property at their parish churches, and makes significant reference to the penalties provided by Parliament for such offences. The sheriff's order provided that the magistrates of Inverness should seize all green timber and bark which had been wrongfully acquired and bring it to Inverness for sale. Apparently the Portclair land

formed part of the old barony of Urquhart up to the time of the restoration of the forfeited estates. At that time the section now described as Portclair passed into possession of the Lovat family and was reacquired by the owners of Glenmoriston Estates at a comparatively recent date. The Portclair land was acquired by the Forestry Commission from the owners of Glenmoriston. The old barony of Urquhart included the baronies of Corriemony and Glenmoriston. The earliest reference to the barony is in a deed dealing with the transfer of the property to William Earl of Sutherland: it appears to have had a number of owners thereafter until it was reacquired by the Crown in 1455. In 1509 the barony was granted to Grant of Freuchie and his sons, and thereafter it remained the property of members of the Grant family up to the time when the Grants lost their land in the rebellion of 1745. An interesting part of the grant of 1509 to the laird of Freuchie was the office of forester of the Royal Forest of Cluanie (Clywne). A clear provision was made that the ownership of the forest remained with the King, and a similar clear provision was made in a charter to a later laird in 1694. The exact boundaries of that royal forest are not very clear, but the forest is described by Dr. Mackay as extending along both sides of the Moriston River and Loch Cluanie from the River Doe to the watershed at the eastern boundary of Kintail. Place-names of Glenmoriston show the importance of the case in the early history of the glen. Two adjustments, at least, of the ecclesiastical parishes of Glenmoriston have taken place since 1600.

CLIMATE.

There is no meteorological station in the forest; the nearest official station is at the abbey at Fort Augustus: this station is about 4 miles from the centre of Portclair. The climatic conditions of Portclair are favourable for the growth of conifers. In normal years there are no severe frosts, and late and early frosts are not common. Rainfall is evenly distributed throughout the year.

The normals of temperature for the period 1881–1915 at the official station at Fort Augustus were:

	Max.	*Min.*	*Mean.*
	°F.	°F.	°F.
January . . .	42·8	32·6	37·7
February . .	43·4	32·0	37·7
March . . .	46·0	33·4	39·7
April . . .	51·2	36·5	43·9
May . . .	56·2	41·2	48·7
June . . .	61·7	46·8	54·3
July . . .	63·5	49·8	56·7
August . . .	62·8	49·6	56·2
September . .	59·8	45·6	52·7
October . . .	53·0	40·4	46·7
November . .	46·9	36·7	41·8
December . .	43·3	33·1	38·2
Mean . . .	52·5	39·3	46·2

The rainfall observations for the same period, 1881–1915, were:

January	5·4
February	4·19
March	3·64
April	2·56
May	2·38
June	2·03
July	2·80
August	3·47
September	3·40
October	3·94
November	4·58
December	5·81
Total	44·20

Within the boundaries of the forest there is a local variation in the general temperature conditions and in the soil-moisture conditions which is reflected in the ground vegetation cover. The valley of the River Moriston runs more or less east and west, and the Commission's land in that valley faces north. During winter little of the direct heat of the sun reaches the soil, and winter frosts last, therefore, much longer in this valley than in the main valley of Loch Ness. The winter frosts do no serious injury in the plantations, but in the formation period of the forest they have frequently delayed work in winter, and on that account have probably received undue consideration.

The limited experience given by the May frosts of 1935 suggest also that the Invermoriston valley area may be more liable to suffer from late frosts than is the valley of Loch Ness, but even in that frost of 1935 the amount of injury caused was surprisingly little. It is difficult to separate the temperature and evaporation effects on the soil conditions and the low vegetation ground cover from the effects of the tree crop, but a very obvious difference is the increasing predominance of *Vaccinium Vities-ideae* in the *Calluna* ground as one goes west along the valley. A good contrast of extremes can be used by comparing P. 32[1] adjoining Inchnacardoch or the upper slopes of P. 27 and the middle slope region of P. 33, P. 28, and P. 25.

GEOLOGY AND SOILS.

The area has not been surveyed in detail by the Geological Survey, hence geological memoirs and maps and soil maps of the area are not available, and the statements made below are, therefore, subject to correction and revision. The rocks of the area are mainly compact hard muscovite and biotite schists of the Moine series. The muscovite schists predominate and weather more slowly than do the biotite schists, which have been seen only in scree blocks on scree faces and in a stream. In the adjoining forest, Creagnaneun, the biotite schist can be seen in soft narrow bands in very hard compact finely crystalline schists. The muscovite schists of Portclair show the muscovite most clearly when split

[1] P.=Plantation; the number following indicating the winter of the year in which it was formed. E.g. P. 32 means a plantation formed during the winter 1931–2.

along the foliation planes. It is then seen in flakes that are sometimes as big as a penny. When the rock face exposes the 'end' view of the foliation planes the rock weathers in furrows parallel to the planes in which the rock is folded. Good exposures of this kind occur above P. 20 and above P. 24, and they can be seen for a considerable distance. West of P. 29 the schists are more compact, weather more slowly, and are apparently more finely crystalline. Above the more or less continuous cliff face which runs parallel to the lines of the valleys of the Moriston River and Loch Ness, the folding planes of the schists can be seen to be fairly flat. The value of the soil is determined by the configuration of the underlying rock and by the distribution and nature of the drift and wash cover. It seems possible that none of the soil which is capable of carrying trees is the direct weathering product of the rock or drift over which it is lying, because of wash. The drift left by the ice in the valleys is mainly a light gritty drift, grey in colour. Three types may be distinguished; possibly they differ less in essential nature than their appearance at first suggests, and differ mostly in the amount of stones and coarse material present. The ice deposits are as follows: (*a*) very small patches of grey plastic material may be seen about the level of the cross rides of P. 35; (*b*) closely packed grey gritty material with relatively small amount of stone can be traced on a line about the lower cross ride of P. 28, and it is to be seen also on the main road along Loch Ness side; (*c*) patches of the same gritty material with numerous and big stones can be seen most easily on the terrace of P. 32. A good sample of (*c*) also can be seen in the quarry hole on the roadside close to the Portclair–Inchnacardoch march. All these drifts are relatively impermeable to water, and when they occur they prevent the vertical passage of drainage water.

For descriptive purposes the area may be divided into two main divisions, shown on the sketch-map by a heavy dotted line: this line appears to run fairly near the level where the ice drift is continuous.

Below the line the soils are of a quality as high as we are likely to obtain for forestry purposes in Scotland, and a complete forest crop can be established without any serious gaps in the crop on account of rock outcrops or shallow cover and impermeable drift. The lower division does not show a uniform soil character. It is not possible to give soil profile descriptions that are descriptive of average conditions.

In the Glenmoriston area, patches of fine-grained, red, alluvial material and wash occur in small patches along the lower hollows of P. 36, P. 35, and P. 30. These originate probably from the stream running into the Moriston River. They lie over coarse river gravels. A more extensive alluvial flat extends along the bottom of P. 31, and in the P. 31 flat the alluvial material is of a coarse-grained character. The alluvial material may be 36 inches in depth, and it also lies on the top of coarse gravels. Patches of gravel moraines and glaciated rock hummocks occur at the lower edges of P. 25*a* and P. 33. On the gravel moraines the common conditions are, 5 inches *Calluna* peat, 7 inches grey leached coarse sand on red rusty-stained sand of variable depth over gravel. At the north-west corner of the forest an area is shown on the sketch-map in which the wash

soils are generally deep (up to 18 inches), and the vegetation cover is luxuriant and rich in species; the material underlying the wash is glacial drift or rock; the amount of leaching is very small; and the birch crop is of good quality. On the remaining portion of the Glenmoriston valley the land below the line is composed

TEXT-FIG. 1. Sketch-map to show main divisions of types of soil.

of scree slopes; the convex slopes have very shallow wash cover; and the flat and the concave slopes and hollows may have 40 inches of soil easily penetrable for roots. On very steep scree the soil may be only in small pockets and patches among coarse angular stones which carry a vegetation rich in species. In places, springs and small landslides have exposed patches of grey gritty glacial drift. On the margin between P. 20 and P. 21 a series of five pits was taken distributed from top to bottom of the plantations. At the bottom of the hill there is a depth of 9 inches of leached grey soil over gritty drift. In the cross-

ride area of the hill there is no marked leaching; the soil utilized by roots is 17 inches deep; the colour of the soil is deep red down to 17 inches, and below that depth there is 22 inches of soil slightly lighter in colour than the soil with roots; grey gritty drift appears below this. The angle of the surface slope is about 32°. Close to the upper limit of the planting there is a depth of 19 inches of dark red soil, showing no marked leaching, resting on rock and worked to the full depth by roots; here the angle of the surface slope is about 35°.

In the Loch Ness valley the scree slope below the line from P. 24 to P. 25 is narrow; there is a terrace of irregular width of good wash soils over gravel and glacial drift, and leaching in this area is unimportant; depth of the wash soil is usually about 15 to 18 inches; in places, springs have washed off much of the material above the hard drift of rock; and rich *Myrica-Molinia* hollows and flushes occur in relatively small patches. The same good conditions as in P. 24–35 terraces appear again in P. 27, but here there is a rough scree area just below the map line. P. 22 below the line and the west section of P. 34 have no lower terrace, the soil conditions are drier than in the P. 24–35 stretch. Patches of hard packed glacial drift are exposed in the margin between P. 35 and P. 22; the soil conditions are, however, probably similar but drier owing to the slope.

Above the heavy dotted line, and in P. 32, the soil cover is broken and interrupted, soils are shallow and lie on patchy drift or rock, and on this area leaching is common and flushes are relatively poor.

VEGETATION.

The natural vegetation-type is birch–pine–oak forest. Small areas of the land now occupied by P. 34, P. 29, P. 24, P. 32 were previously enclosed, and part was cultivated. The forest also had patches of ash on low land by the river and loch, and on the scree face near the top of P. 27. Aspen occurred chiefly on the alluvial flat below P. 31 and P. 23. Alder, although it occurs quite commonly, has always been a tree of very secondary importance in the forest. Hazel is plentiful on the lower slopes of the forest. Mountain ash, juniper, and willows (chiefly *Aurita* and *Caprea*) are common; holly is scarce.

The vegetation of P. 32 area and the upper regions of the shallow soil region above the line shown on the map is predominantly a *Calluna, Erica, Molinia,* and *Myrica* area with relatively few additional flowering species. The richer flushes may have good *Molinia* and *Myrica* cover: the lower end of the scale is a cover of *Calluna* with much *Scirpus* and stunted creeping *Molinia.*

Below the line shown on the sketch-map the great part of the area falls into two main divisions: (*a*) the terrace above Loch Ness carries a grass, bracken, and herb-rich vegetation: the flushes and skinned flats carry a rich *Molinia, Calluna, Myrica Holcus* type of cover; (*b*) the scree and covered scree slopes have a vegetation that is very rich in species: a list of vegetation found on the scree faces, which is incomplete, will give an idea of the cover.

P. 22. (Above cross ride close to east margin of P. 27. Noted on an area of less than one-tenth of an acre on a thinly covered scree.) *Calluna, Erica Tetralix* and *v. cinerea, Vaccinium Myrtillus* and *V. Vitis-idaea, Molinia, Aira flexuosa,*

Festuca ovina, *Bromus*, *Arrhenatherum*, *Nardus*, *Agrostis*, *Holcus*, *Anthoxanthum*, *Galium saxatile*, *Potentilla*, *Viola*, *Primula*, *Scilla*, *Prunella*, *Trientalis*, *Hypericum*, *Teucrium*, *Spiraea*, *Lathyrus*, *Anemone*, *Veronica*, *Mercurialis*, *Senecio jacobea*, *Trollius*, *Blechnum*, *Carex binervis*, *Betula*, *Pyrus aucuparia*, *Scabiosa*. Variations in the frequency of the plants are innumerable, but the ruling plants are *Calluna*, *Erica*, and grasses. There is an interesting variation already referred to in the amount of *Vaccinium Vitis-idaea*, which appears to increase in amount from the mouth of the Moriston valley westward until, along with *Calluna* and small amounts of *Vaccinium Myrtillus*, it forms the ruling cover over large areas. Those areas are broken up into irregular small hummocks of *Calluna*, *Vaccinium*, and *Sphagnum*; between the hummocks there are *Sphagnum* hollows. Another interesting feature is the distribution and association of *Mercurialis*, which is found in strange company; *Oxalis* and *Lonicera* also are strangely distributed. In patches (as for example top scree of P. 27) the ruling cover is *Aira flexuosa*, *Vaccinium Vitis-idaea* and *Galium saxatile*, and here it appears strange also to find ash seedlings plentiful. The deep-soil triangle in the north-west corner of the forest has a mixture of the two main sets of associations, viz: grass, bracken herb-rich type, and *Calluna*, with numerous species of flowering plants. The alluvial flat has mainly a grass herb-rich cover, and the number of species found in the flats is greater than that on the scree slopes. On the gravel moraines *Calluna* is the ruling plant, the grass is chiefly *Aira flexuosa*, Sheep's fescue, and Agrostis, the number of occasional species is small.

PREVIOUS UTILIZATION.

The area includes small areas which were formerly enclosed for grazing and cultivation; those areas are on the terrace land of the plantations now known as P. 32, P. 34, P. 29, P. 27. At the time of acquisition practically all the timber had been sold, with the exception of about 50,000 cubic feet of spruce, larch, and Scots pine; with about 15,000 cubic feet of oak and about 5,000 tons of birch of which part was saleable. The larch and Scots pine taken over by the Commission were mainly in the south-west corner in the area now known as P. 32. The spruce were mainly in P. 24 and P. 27, and included a fairly complete plantation of about 7 acres. Spruce formed about 66 per cent. of the total volume of coniferous timber taken over by the Commission.

It was estimated that at 1913, when the main timber sale took place, that there were about 500 acres of natural pine-birch forest in Glenmoriston: the area now occupied by P. 32 was in 1913 covered by a plantation probably about 40 years of age and consisting mainly of Scots pine and European larch; this plantation had been made during the time when the estate was Lovat property. The areas now occupied by P. 20 and P. 21 were covered with a birch crop. The rest of the area carried the timber and scrub sold to the Commission.

At the time of acquisition the P. 32 area had been practically cleared, P. 20 and P. 21 had been felled, and 200 out of the 500 acres of the natural pine had been cut. The sales of the timber purchased by the Commission were completed about 1929.

The early workings in the forest have been referred to already. In the hundred years preceding the acquisition by the Commission the area had been worked intermittently for timber and bark, and it also gave a valuable shelter to deer in hard weather. It is worth noting that alder does not appear to have been worked at any time by clog makers or turners. The estate sold birch timber in the round for bobbin making, and in 1910 they installed machinery for making rough bobbins. That machinery worked up to the end of the war. The area was never grazed heavily by sheep, but deer and rabbits certainly restricted natural regeneration of the pines and birch. Heather burning seems to have contributed to the deterioration of parts of the thin soil tops and fringes of the wood.

REAFFORESTATION.

Planting work began in 1920 and will finish in 1937. In that period the total planting will amount to approximately 2,400 acres, which is substantially the forecast made at the time of the acquisition. The distribution of species used in the planting is:

Scots pine	9 per cent.
European and Japanese larches .	3 „
Douglas fir	26 „
Spruces (Norway and Sitka) .	60 „
Various	2 „
	100 „

Fully 60 per cent. of the plantations are already in a satisfactory condition.

In the earliest plantations on unsaleable birch scrub land, the land was cleared from scrub, and the planting was on bare land. In later plantations the scrub was ringed and allowed to die. The ringing work cheapened the preparation very greatly. Ringing was work that could be carried out in advance of other preparatory work during weather when other operations were impossible, and on that account it was always well in advance of other such work. When at a later date it was desired to modify the scrub treatment, the change was delayed by the amount of advance work. In the plantation of 1935, 1936, and 1937 the plantations in scrub will be made with the least possible cutting or ringing of the birch, and the removal of the birch will be done as the young crop develops. In these later planting operations the plants are to be kept about 3 feet from any scrub tree, and the spacing between plants will be varied according to the size of the clear spaces between scrub trees. The later treatment of the scrub will depend on the growth of the planted trees. In the early scrub work Douglas fir was used extensively. The choice of Douglas fir was a natural one on account of its shade-bearing character and the resistance of the tree in early life to root fungi, which are common on hardwood scrub areas. In later years the Douglas fir was replaced largely by Norway spruce and to a much less degree by Sitka spruce. In Portclair it can be said that Douglas fir has up to the present been more successful than in any other forest in the division. The trees have proved themselves more wind firm than in most places; they

have suffered little from insect and fungi enemies, although they are going through an attack of *Chermes*. At the present time, when Douglas fir is rather unpopular, the growth on Portclair serves as a useful help in keeping a fair balance. Attention might be specially drawn to the east margin of P. 24 and to parts of P. 31; these are not areas of the fastest growth, but areas where comparison with other species, Scots pine and Norway spruce, can be made easily. Douglas fir has been planted in a fairly wide range of soil conditions. It has been most successful when planted over gravel in soil that is well drained.

In this forest the use of Scots pine was confined mainly to shallow *Calluna* ground of a very moderate quality. Sitka spruce was used freely on fresh shallow soil in moist patches and in Douglas fir woods for narrow fairly acid hollows between hillocks, and also with less success on shallow *Calluna* peat over shallow soil on drift and rock. It has been very successful on *Calluna—Myrica—Molinia* vegetation; on account of its liability to suffer from early attack of root fungi its use in scrub land was restricted, and the precaution seems to be a sound one. Since 1927 the trees have been mostly planted on raised mounds on soil that has been drained. The attention given to draining has been increased since 1927. Norway spruce was used in most grass land. The remarkable success of the Norway spruce planted in the scrub *Calluna—Vaccinium* vegetation of P. 25 has encouraged the wider use of the common spruce for such work, and it has now almost displaced the use of Douglas fir for that work. Larch was almost excluded from use in reafforestation of this forest. This is explained chiefly by the presence of the scrub on the qualities of land judged suitable for larch.

TYPES AND QUALITY OF PRODUCE.

Pine. The natural pine remaining at the time of acquisition was described as being about 200 years old on the average. The crop had few young trees; the form of crowns included all variations from pyramidal to broad umbrella shapes; and if one can judge from the survivors on Portclair and Inverwick they were short stemmed in most cases. The quality of the timber is excellent. Trees with a girth of 80 inches at breast height were fairly common.

Larch. The average volume of the larches produced on the area ran to about twenty cubic feet quarter girth per tree, but specimens up to fifty cubic feet were cut. This growth was very satisfactory for the period of production. Good shore poles of 60 to 70 feet were common. The quality of the larch was very good.

Norway spruce. The tree did exceptionally well. The average yield for the 7-acre solid block of 40 year-old spruce was about 4,800 cubic feet per acre; and one small plot within the spruce area gave a yield of 6,200 cubic feet quarter girth per acre.

Oak. The area is not one that is likely to produce a large quantity of good quality oak, although isolated trees of good form can be seen.

The figures for the planted crops are as yet of little value, but two measurements of small plots taken in the plantation of year 1924 in January 1935 may

PLATE XI

1. Covered scree faced shading into loch terrace. Note influence of concave and convex slopes

2. Looking down on P. 24 and P. 29. Plantations are partly on Loch terrace sands and partly on 'wash' lying over drift

3. Slope scree covered, grading on to an alluvial terrace

4. Invermoriston valley. Note influence of minute topography on soil value. Good fertile land on first terrace above a scrub

PLATE XII

1. Looking across P. 22 eastwards. 'Wash' surface over drift

2. P. 24. Showing scrub ringing and growing crop of Douglas fir

3. P. 27. Norway spruce in ringed oak scrub

4. *Armillaria* hole in Sitka spruce. P. 22

be mentioned. The Douglas fir suffered from an attack of *Chermes* in 1933 and 1934, and shoots for these years were short, but the trees showed an average height growth of 22 feet. A Sitka spruce plot showed an average height growth of 17 feet. The Sitka spruce had not been planted on mounds. The plots were taken in places which were very favourable to the species.

PROTECTION.

Up to the present time the forest has not suffered very severely from any animal, fungus, or insect pest.

In the years up to about 1931 Douglas fir suffered a little from an attack of *Phomopsis*; the attacks are less severe now. Small areas of Sitka spruce have been killed by *Armillaria* (1922 plantations).

Hylobius abietis caused injury for 4 or 5 years after the felling of the Scots pine: this attack has now died down. *Chermes Cooleyi* appeared in the forest about 1929, and since that date it has been spreading. Black-game are a severe check to Scots pine growth, especially in 1929 planting. They give a check period of 5 to 6 years on Scots pine, even in places which are favourable to that tree. Capercailzie apparently died out about 1758: 'The Capercoille (or wild turkey) was seen in Glenmoriston about 40 years ago and it is not known that this bird has appeared since or that it now exists in Britain' (statistical account of 1798). Unfortunately it is probable that the capercailzie will soon become common on the area. The original source of reinfection of the valley is said to be Guisachan, where the birds were first reared about 35 years ago.

Roe-deer are a continual annoyance to the forester, but the amount of damage done is not severe. Red deer are excluded by a deer fence which runs around the greater part of the forest, but although the forest is not completely enclosed, only an occasional red deer wanders in. Rabbits are kept down by shooting and snaring; part of the west boundary is rabbit netted.

Winds and storms have not caused damage to date but some wind damage may be looked for, especially in the valley of Loch Ness and in the mouth of Glenmoriston.

THE SOILS OF DRUMMOND HILL

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INTRODUCTION.

DURING a short visit to Drummond Hill in 1934 a few soil pits were examined and sampled. The object of this note is to give a short account of these soils as a supplement to Mr. Murray's article in No. 1 of this volume (5). Since the locality conditions have been fully described in that article they need not be repeated here. Three soils will be described: one on the southern slope, one on the summit, and one on the northern slope. For comparison with that on the southern slope, data for a soil from Lael Forest in Ross-shire will be given.

METHODS.

The field and laboratory methods have been already described (4), with the exception of two new determinations which were not then carried out. Carbon was determined by the method described by Robertson and Shewan (6), and nitrogen by the ordinary Kjeldahl method. The acid oxalate extract was carried out as prescribed by Tamm (10, method A).

MORPHOLOGY OF THE SOILS.

The soils will be considered in pairs, taking the one on the southern slope of Drummond Hill and that from the Lael Forest first.

Profile D. 1 (Drummond Hill Forest).

This soil was examined in the experimental block on the southern side of the hill.

Vegetation: Grasses, *Pteris aquilina*, *Galium saxatile*, Larch races experiment.

Height: *c.* 400 ft. Angle of slope: 15–20°.

Description: (1) 0–30 cm. Brownish-grey loam; soft crumbly structure; loose and friable, stones frequent; many roots.

(2) 30–100 cm. Medium brown light loam; fairly compact, yet free; stones common; roots cease about 80 cm.

This soil bears a striking resemblance to a type found in the Lael Forest in Ross-shire. This type was observed there on both sides of the valley of the River Broom, and the example given was taken in the south-west corner of the experimental area. The hills rise fairly sharply from the valley and flatten out near the top.

Profile B. 1 (Lael Forest).

Vegetation: *Pteris aquilina*, grasses, *Galium saxatile*; mosses including *Hylocomium triquetrum*, *Hypnum splendens*, *Bracithecium purum*. Small natural birch and planted Douglas Fir.

Description: (1) 0–15 cm. Greyish-brown loam; soft crumb structure; friable; small stones common; dense root-system.

(2) 15–120 cm. Light-brown light loam in between large boulders or solid rock (biotite schist), loose and friable; small stones and bits of rotten schists common; roots cease about 115 cm.

There is a slight difference in the depth of the horizons between these two soils, and rock, or large boulders, occur in one, but otherwise they resemble each other closely. The mineralogical composition[1] of the lowest layers of these two soils differs somewhat. D. 1 contains quartz, biotite, muscovite, hornblende, iron-oxides, felspar, garnet, and tourmaline. B. 1 contains quartz, biotite, felspar, iron-oxides, zoisite, zircon, and garnet. The hornblende in D. 1 is derived from the epidiorite and hornblende schist which occurs on the top of the hill. It is seen that there is no muscovite in B. 1, and the zoisite here is derived from a band of zoisite rock in the granulitic schists of the district (2). The tourmaline and zircon are present in very small amounts. The annual rainfall at the two localities differs widely: that at Drummond Hill is about 36 inches, while at Braemore it is about 60 inches. What appears to be the most important feature leading to such a development of these two soils is the slope on which they are found. This will be made more apparent in the discussion of the chemical analyses. From the silvicultural point of view an interesting feature is that these two soils are both excellent larch soils.

The next two soils are those from the summit and the northern slope. The slope is covered with till and morainic drift, according to the geological map, and the top of the hill is drift-free. From what was seen, there is little difference between the till and the material on the summit. Both are very coarse textured (71 per cent. coarse sand in the lower layers of profile D. 3) and nearly all the stones are local. This is also shown by the mineralogical analyses.

Profile D. 2.

This soil was examined on the summit of the hill about 30 yards north of the boundary dyke.

Vegetation: *Vaccinium myrtillus*, *Calluna vulgaris*; mosses including *Hylocomium splendens* and *Hypnum schreberi*. Old tree stumps on surface.

Height: *c.* 1,300 ft. Flat spot.

Description: (1) 0–10 cm. Dark brown to black *Vaccinium* and *Calluna* mor;[2] very compact, stones occasional.

(2) 10–15 cm. Medium, to light, grey silty loam; smears; stones and roots frequent; not compact.

(3) 15–40 cm. Rich-brown crumbly loam; stones frequent, fewer roots; more compact than preceding.

[1] Determined on the fine sand fraction (0·2—0·02 mm.).

[2] This term was reintroduced at the Nancy Conference of the International Union of Forest Research Organizations and was confirmed by the Forest Soils Sub-Commission of the International Society of Soil Science this summer.

(4) 40–60 cm. Yellowish-brown, shading into fawn sandy loam; stony and compact; roots occasional.

(5) 60 cm.+Rotten rock.

Profile D. 3.

This profile was examined on the northern slope.

Vegetation: *Calluna vulgaris*, *Vaccinium myrtillus*, occasional *Pteris aquilina*; mosses, including *Hypnum schreberi* and *Hylocomium splendens*. Scots pine planted.

Height: 700 ft. Angle of slope: 5°.

Description: (1) 0–10 cm. Dark-brown *Calluna* mor; occasional stones.

(2) 10–20 cm. Medium, to light, grey sandy loam; stones and roots common; small patches have a greenish tint.

(3) 20–35 cm. Yellowish-brown loam; soft crumb structure; stones frequent; roots becoming rarer and ceasing about 35 cm. In places there is a thin iron pan at 20 cm.

(4) 35–80 cm. Yellowish-fawn, merging rapidly into fawn, loamy sand; stony and extremely compact; boulders common. The stones appear to be nearly all schists and many are rotten.

It is obvious that both these soils are strongly leached and could, on a morphological basis, be called strongly podzolized soils, or even podzols, since there is no indication of an A_1 horizon below the mor layer in either (4). In addition to being podzolized, D. 3 shows distinct evidence of gleying in the leached layers (the presence of greenish spots), and there are the beginnings of hard-pan formation below this. This soil would therefore be best described as slightly gleyed, strongly podzolized.

The writer has already suggested various possible explanations for the development of gleying in the leached horizon (4), and it would seem that one of these is applicable to this case. The soil does not appear to have been under forest within recent times and the compact *Calluna* mor is old. This layer of mor on the surface has a very high absorption capacity for water and would, therefore, keep the leached layer in a moist condition. The organic matter in the mor would not be fully oxidized, and any passing down through the leached layer would tend to be oxidized at the expense of the ferric iron compounds present. The little green spots formed would then gradually grow in size until the whole layer assumed this tint. The ferrous compounds would be leached out gradually, and as they entered a layer with better aeration would be oxidized to the ferric state and precipitated. This point would probably be fairly well marked and an iron pan would result. This process has evidently not been going on long in D. 3, for the pan is thin and discontinuous, and the greenish colour in the leached layer is only in spots. Now that the area has been afforested, the gleying process will probably cease, since the *Calluna* mor will gradually disappear once the trees form canopy. Better conditions of aeration will then prevail. If afforestation had not been carried out it is quite possible that the soil would have gradually deteriorated, and something

approaching the peaty gley podzols of the Teindland type would have been formed. It would be interesting to re-examine this soil when the trees are well grown; confirmation of the above might then be obtained.

D. 2 was until recently under forest and the present mor layer is of more recent origin than that on D. 3. This fact no doubt explains lack of evidence of gleying in the leached layer of D. 2. It may possibly have begun now, but so far it is not visible.

CHEMICAL ANALYSES OF THE SOILS.

In Tables I and II are given the data for the first two soils, D. 1 and B. 1. These are both acid but not so acid as D. 2 and D. 3, and as would be expected

TABLE I. *Analytical Data for Profile D. 1*

Depth.	*0–10 cm.*	*20–30 cm.*	*30–40 cm.*	*90–100 cm.*
pH	5·26	5·35	5·24	5·36
Clay, %	16·25	14·87	8·87	5·85
Exchangeable Ca (m. eq.)	3·2	2·4	1·2	0·6
„ H (m. eq.)	9·7	5·9	3·6	2·4
Clay fraction SiO_2/R_2O_3	1·51	1·45	1·03	0·86
„ SiO_2/Al_2O_3	1·93	1·92	1·59	1·16
„ SiO_2/Fe_2O_3	7·04	5·92	3·83	3·00
„ Al_2O_3/Fe_2O_3	3·64	3·08	2·70	2·86
Acid oxalate Fe_2O_3, %	0·64	3·00	0·69	0·43
„ Al_2O_3, %	0·55	1·75	0·64	0·44
Organic carbon, %	2·93	1·88	0·85	0·31
„ nitrogen, %	0·119	0·097	0·05	..
C/N	24·6	19·4	17·0	..

TABLE II. *Analytical Data for Profile B. 1*

Depth.	*0–15 cm.*	*15–25 cm.*	*30–40 cm.*	*50–60 cm.*	*100–120 cm.*
pH	5·13	5·19	5·30	5·30	5·32
Clay, %	13·36	11·10	8·32	5·44	7·32
Exchangeable Ca (m. eq.)	2·5	1·0	0·8	0·6	0·6
„ H (m. eq.)	14·3	13·4	11·7	10·1	8·8
Clay fraction SiO_2/R_2O_3	1·05	0·71	0·69	0·67	0·43
„ SiO_2/Al_2O_3	1·56	1·15	1·23	1·19	0·54
„ SiO_2/Fe_2O_3	3·18	1·82	1·57	1·52	2·22
„ Al_2O_3/Fe_2O_3	2·40	1·58	1·28	1·28	4·11
Acid oxalate Fe_2O_3, %	1·62	2·20	2·16	1·76	0·97
„ Al_2O_3, %	1·00	1·16	0·77	0·93	2·55
Organic carbon, %	5·18	3·21	n.d.	n.d.	n.d.
„ nitrogen, %	0·317	0·186	n.d.	n.d.	n.d.
C/N	16·35	17·30	..	..	..

the exchangeable calcium is low. Exchangeable magnesium is not given, the amounts in all cases being extremely small. The most interesting figures for

these soils are the silica-sesquioxide ratios in the clay fractions and the amounts of ferric oxide and alumina, extracted by the acid oxalate solution. The figures for the latter determinations show quite a definite leaching of sesquioxides and their deposition at a shallow depth. The clay fraction ratios, on the other hand, show no such deposition. The surface soil in each profile would appear to have been leached, since the ratios decrease right down to the bottom. Only in B. 1 is there a rise in the SiO_2/Fe_2O_3 and Al_2O_3/Fe_2O_3 ratios in the lowest layer. The SiO_2/Al_2O_3 and SiO_2/R_2O_3 decrease to extremely low figures. In a recent paper (3) R. L. Mitchell and the writer suggested that this type of soil is due to the modification of the vertical leaching by the lateral washing of weathered material. This, however, does not cover all the observed facts. The oxalate extracts show a marked divergence from the clay ratios in that they show a definite accumulation of sesquioxides in the sub-surface layers with a subsequent falling off in the amount extracted. In this respect the soils resemble D. 2 and D. 3 to some extent. These differences may be explained as follows. The acid oxalate solution removes, for the most part, these sesquioxides which have only recently been set free by weathering, or deposited after leaching, while the clay fraction includes sesquioxides which are bound up with silica as well as sesquioxides *per se*. Although the clay fractions of the lower layers contain more iron than the upper ones, this is not removable by the acid oxalate. It must then be bound up in some way. This suggests that a recombination of weathered and deposited materials has taken place. Rodé (8) has already shown that a recombination of leached substances must take place in some Russian soils, so that there is no reason why this should not be the explanation of the present discrepancies.

The nitrogen figures for the surface layers of these soils are not very high, and the amount falls off fairly rapidly with increasing depth. The C/N ratios are interesting. In the residues from vegetation a ratio of about 40 : 1 is obtained; as this organic matter is converted into humus, carbon is lost, and the ratio falls to about 10 : 1 (7*b*). It would seem, therefore, that a certain amount of non-humified material is included in the carbon values for these two soils. The effect of vegetation must, of course, be considerable, but so far insufficient data are available for further discussion.

Soils similar to the above have been reported in Wales by Robinson (7*a*), who calls them eroded podzols, but the extremely high sesquioxide content of the lowest layers of the present soils does not support this description. It would probably be better to call them *creep soils* (1), since up to the present they have only been found associated with steep slopes.

In Tables III and IV are reported the analytical data for profiles D. 2 and D. 3. The mor layers are seen to be extremely acid, with high exchangeable hydrogen; the exchangeable calcium is also comparatively high. The sudden drop in these figures on passing into the leached layer is very characteristic for soils of the podzol type. The clay ratios clearly show the strong leaching which has taken place, and the acid oxalate values bear this out. Both sets of figures show that much more iron has been removed from D. 2 than from D. 3.

TABLE III. *Analytical Data for Profile D. 2*

Depth.	*0–10 cm.*	*10–15 cm.*	*15–25 cm.*	*30–40 cm.*	*50–60 cm.*
pH	4·06	4·27	4·90	4·89	4·89
Clay, %.	..	11·86	11·70	12.84	7·41
Exchangeable Ca (m. eq.)	7·13	0·8	0·6	0·6	0·7
„ H (m. eq.)	95·6	10·9	19·1	8·5	4·9
Clay fraction SiO_2/R_2O_3	..	2·15	2·00	0·87	1·19
„ SiO_2/Al_2O_3	..	2·26	2·21	1·27	1·68
„ SiO_2/Fe_2O_3	..	41·65	2·26	2·73	4·10
„ Al_2O_3/Fe_2O_3	..	18·42	1·02	2·14	2·44
Acid oxalate Fe_2O_3, %	..	0·16	4·57	2·08	0·74
„ Al_2O_3, %	..	0·25	2·78	1·80	0·82
Organic carbon, %	24·4	2·21	4·09	1·58	0·70
„ nitrogen, %	1·64	0·039	0·174	0·090	0·05
C/N	14·9	57·0	23·5	17·5	13·5

TABLE IV. *Analytical Data for Profile D. 3*

Depth.	*0–10 cm.*	*10–20 cm.*	*20–30 cm.*	*40–50 cm.*	*70–80 cm.*
pH	3·79	4·24	4·90	5·01	5·29
Clay, %.	..	14·82	12·03	9·49	4·97
Exchangeable Ca (m. eq.)	7·56	0·7	0·6	0·6	0·8
„ H (m. eq.)	74·0	16·6	12·6	3·7	1·8
Clay fraction SiO_2/R_2O_3	..	1·84	1·04	1·10	1·21
„ SiO_2/Al_2O_3	..	2·03	1·65	1·67	1·55
„ SiO_2/Fe_2O_3	..	20·58	2·79	5·26	5·38
„ Al_2O_3/Fe_2O_3	..	10·16	1·69	1·95	3·47
Acid oxalate Fe_2O_3, %	..	0·39	2·87	0·49	0·49
„ Al_2O_3, %	..	0·38	1·18	0·86	0·64
Organic carbon, %	41·60	3·75	2·30	0·48	0·46
„ nitrogen, %	1·21	0·24	0·12	0·05	0·05
C/N	34·54	15·6	19·2	9·6	9·2

Mineralogically these two soils are derived from the same parent material, the composition of which is: quartz, biotite and muscovite, felspar, iron oxides, garnet, hornblende, tourmaline. It is seen that this is the same as for D. 1. Layer 2 of D. 2, the grey layer, shows an almost complete absence of ferromagnesian minerals: the result of the strong leaching which has taken place. While D. 2 is more strongly leached than D. 3, its grey layer is only half the thickness of that in D. 3. The greater depth in D. 3 may, of course, be a result of the washing down of partially leached material from higher ground after burning or deforestation in some former time. The iron in D. 2 has been carried down to a much greater depth than in D. 3, and the sharp change in the iron values in passing from layers 3 and 4 of D. 3 may be connected with the gleying process which is now taking place in the grey layer. It was mentioned in the section on the morphology of the soils that the point of oxidation and

precipitation of the ferrous compounds leached out of the gleyed horizon would probably be very sharply marked in the profile. This suggestion seems to be borne out by the chemical analyses, and it is quite likely that the formation of hard pan is due to this well-defined zone of precipitation.

In Sweden, Tamm (9) has found that the ground vegetation is closely connected with the degree of podzolization: the most strongly podzolized soils are found under a ground vegetation dominated by *Vaccinium myrtillus*, whereas under *Calluna* the soil is not nearly so strongly leached. It is quite possible that this may be the reason for the greater leaching in D. 2, since *Vaccinium myrtillus* is the dominant plant on the site of the soil pit.

The carbon and nitrogen figures are rather interesting. There is a very marked difference between the carbon contents of D. 2 and D. 3, and it seems as if this might be connected with the degree of decomposition of the raw humus layer. The C/N ratio in layer 1 of D. 2 is 14·9 and that in layer 1 of D. 3 is 46·6. From what was said about these ratios in discussing the first two soils, it would seem that the mor layer of D. 2 is much more strongly humified than that of D. 3. This is to some extent borne out by the morphological descriptions: layer 1 of D. 2 is black, that of D. 3 is brown. The obviously wet condition of D. 3 would also tend to inhibit active oxidation.

In the other layers of D. 3 the carbon and nitrogen gradually decrease, whereas in D. 2 there is a very sharp rise in the third layer, after which the values again decrease. This marked increase in the illuvial horizon has been noted elsewhere, and Weiss stresses this point in his papers on the Danish heath soils (11). The nitrogen in these lower layers is considered to be in an easily available form and was one of the reasons why Weiss advocated the turning up of the subsoil in the reclamation of heath soils.

SUMMARY.

Morphological description and chemical analyses of three soils from Drummond Hill and one from Lael are given, and their relation to topography and other natural factors are discussed. The soil on the south slope of Drummond Hill and that from Lael are shown to be closely connected with the steep slopes on which they are found. These are termed *creep soils*. These two soils appear to be excellent for larch. The other two soils are strongly podzolized and one shows gleying in the leached layer and the beginnings of a hard pan below it. Scots pine is growing quite well on the latter soil.

I have to thank Dr. R. Hart for making the mineralogical analyses which are quoted in this paper, and Miss A. I. Bell, Mr. H. Hardy, and Dr. R. L. Mitchell for carrying out a number of the chemical analyses.

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NOTE

In his description of the acid oxalate extract Tamm recommends that the extract should be evaporated to dryness in a platinum basin and then ignited. The residue is then scraped out and fused with sodium carbonate. Owing to lack of platinum vessels this could not be done and the following modification was successfully worked out.

The extract is evaporated to dryness in a porcelain basin and then treated with a mixture of sulphuric acid (10 c.c.) and nitric acid (5 c.c.). The whole is warmed over a small flame until evolution of nitrous fumes ceases. Further addition of nitric acid may be necessary if the soil is high in organic matter. When the liquid is quite clear, the basin is cautiously heated until the sulphuric acid is fuming strongly. It is then cooled and the residue dissolved in water, warming on a water-bath if necessary. Silica is then filtered off and sesquioxides determined in the usual way.

BARK-BEETLE OUTBREAKS AND THEIR CONTROL: A REVIEW OF SOME RECENT LITERATURE

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INTRODUCTION.

DURING the past three years several very important contributions have been made to the literature of forest entomology, dealing with the causes and means of control of bark-beetle outbreaks. These papers emanate from three sources: the first from the United States, the second from Sweden, and the third from Poland. They present an interesting up-to-date picture of the bark-beetle problem in three totally different regions, discuss new methods of assessing bark-beetle populations, new control devices, and, in the latter case, a valuable account of work done on the natural enemies of two spruce species with a view of trying to show the extreme importance of these, and urge that the fullest possible use be made by the forester of their services.

WORK IN THE UNITED STATES OF AMERICA.

The first paper (1), from the United States, is part of a report entitled 'The Progress in Forest Entomology and Protection against Forest Insects'. This was prepared in 1933 by the Forest Service of the U.S. Department of Agriculture. A considerable portion of the report deals with the activities of bark-beetles, which are, in the western States at any rate, a constant menace to the forest. The annual toll taken by these insects in the western forests amounts to some 5 or 6 billion feet of mature timber, and over a 10-year period the loss has amounted up to 2·620 million board feet. Much of this damage has been done in the vast areas of the Lodgepole pine. A recent survey in the State of California, the paper tells us, 'showed that the forest losses due to bark-beetles were at least 2·25 times as great in 1931 as they had been on the average for the past 10 year period'. Apart from serious commercial loss, considerable damage of an aesthetic nature was also done in cases where valuable old stands in the national parks which were being preserved for their beauty were decimated and disfigured. Through many parts of this western region also the bark-beetle damage causes another and less appreciated form of loss, in that it interferes with the orderly management of certain types of stands. The Western White pine and the Lodgepole pine of the northern Rocky Mountain region afford an excellent example of this. Here, bark-beetle activities often result in effecting considerable alteration in the composition of the stand, the quality of which is often so reduced that an entirely new system of management has to be organized.

The importance of devising and putting into operation control measures against these insects has been realized since 1906, when a sum of 2,700 dollars was expended in one project aimed at the control of the Black Hills beetle. In

less than 30 years this sum has risen to an annual amount of over 250,000 dollars spent by the forest and allied services, while the Bureau of Entomology itself has spent 1,000,000 dollars in the same cause.

Control work has been directed against seven species of bark-beetles, involving an enormous amount of biological and survey work. One of the most promising new methods of control, first tried out in 1926 in an experimental way, is the application of solar heat to infested trees. The trees are felled and pruned, and temperatures between 110 and 120° Fahr. will kill the broods if maintained for two to three hours. Such lethal temperatures are reached in logs which are exposed to full sunlight, lying north and south, between the hours of 10 a.m. and 4 p.m., the air temperature ranging from 80° Fahr. upwards. The logs should lie for a total period of 5 to 10 days, and be completely turned round once during this time. This method has proved effective in the State of Oregon and improved methods of handling have materially lowered the cost of application in recent years. Another control method, which shows some promise, involves the burning of the bark of the trees while still standing. This has been tried out in the Yellowstone National Park. Besides these two mechanical methods there are also some chemical methods, which are still in a very elementary stage of experimentation. The first of these involves the injection of a chemical into the tree to kill the broods and thus aims at evading the usually expensive process of felling and barking. The second, a variant of the first, involves the spraying of chemicals on the bark. Both these are, however, still too undeveloped to show decisive results.

The bark-beetle outbreaks in the United States are spread over such an enormous area that it is neither possible nor feasible to attempt control of them all. The National Park service has, therefore, drawn up a policy of control which provides for full protection to be afforded those areas which are, so to speak, of immediate economic importance, e.g. areas which are in present intensive use and have important aesthetic value, areas likely to come into use in the near future, areas where fire hazard is great, and areas where incipient outbreaks are likely to be controllable with comparative ease. Where timber value is the primary consideration the above lines will, in the main, be followed so far as practicable, taking into consideration such factors as the probable future time of logging, the possibility of salvaging timber killed by the beetles, and the degree of severity which the infestation has reached. As the outbreaks differ from one another in all kinds of degrees it is obvious that co-ordination of the work is no easy matter, but demands a great deal of co-operation between the state and the private owner to ensure its success. As time goes on, the costs of control will rise; they are already heavy, and an enlightened policy can be ensured only if those who vote the funds are fully alive to the importance of the work and the needs to be met. This pamphlet should perform a useful service in providing a clearly written exposition of the facts.

WORK IN SWEDEN.

The second (2) of the three papers to be discussed here comes from Sweden

and was written by Professor Ivar Trägårdh and Dr. Viktor Butovitsch. It bears the title, 'Measures against Bark-Beetles, after the Storm Devastations of 1931–2, in Central and Southern Sweden'. It was published in 1935.

This paper differs from the last in describing the investigation of, and mode of dealing with, a sudden crisis which called for prompt action and far-sighted decisions on questions of future policy. The catastrophe which laid waste the pine and spruce forests of central and southern Sweden was effected by three storms which swept that country in July and December 1931 and February 1932. The first tribute one must pay Professor Trägårdh is in respect to the rapidity with which he organized the entomological investigation, succeeded in obtaining Government sanction and funds for the work, and, by a comprehensive campaign of education, enlisted the support of the foresters as well as the general public in the work. A so-called 'Storm Commission', consisting of Professor Trägårdh and three assistants, was formed and started work in April 1932. Their first task lay in organizing consultations between themselves and the various forest authorities concerned as to the best and quickest methods of removing as much of the fallen timber as possible, so as to lessen the amount available for the bark-beetle hordes, which were surely coming, to breed in. In some parts the success of these measures was very great, no beetle attack developed at all. This was the first important service rendered to the country by the Commission. Soon, however, a time came when it was no longer possible to cope with the work of timber removal, and further studies of the breeding-conditions were begun. In the province of Uppland, for instance, which was one of the districts most heavily damaged by the storm, an area of over 60,000 acres had been storm-felled, involving some 53,000,000 cu.ft. (quarter girth) of timber.

In the initial work on protective measures, trap-trees were the subject of experiment. It was soon obvious that two species of bark-beetle were of primary importance, *Ips typographus* L., the eight-toothed spruce bark-beetle, and *Myelophilus* (*Blastophagus*) *piniperda* L., the pine-shoot beetle. Besides these, there was a host of secondary species of which the most conspicuous was *Ips* (*Pityogenes*) *chalcographus* L. The first work on trap-stems showed that the removal of bark-strips, 4 cm. wide, from all timber over 4 inches diameter effected a reduction in the numbers of *typographus* issuing from such logs of over 95 per cent. For *piniperda*, however, the strip-barking was useless, total barking being cheaper and more effective.

The Uppland storm areas were, however, so widespread and cut up, as it were, into holes (Hygge) of different shapes and sizes that the problem soon arose as to the best method of making a reasonably accurate ecological survey of the whole region so as to arrive at some estimate of the comparative numbers of the important insect species breeding there, and their likely rate of increase. This portion of the work was performed in great detail and constitutes the central *motif* of the paper. A method of linear survey, modified on previous work carried out on forestry problems in Sweden, was adopted, and the main features of this were as follows.

The devastated areas were first of all divided into those which had been left untreated (i.e. no measures had been carried out to deal with the fallen and injured trees) and those in which the trees had been entirely, or at least partially, removed, the injured standing trees having been left. In this second category the areas were again divided into those over 2 hectares (4·8 acres) and those of 2 hectares or less. In both these subdivisions the areas were again separated into those entirely or partially surrounded by forest, and those entirely or partially surrounded by open country, meadows, or fields. The linear survey was essentially simple in working details. Compass lines were run through the area so as to obtain as completely representative a cross-section of it as possible. Along those lines, strips 5 metres broad were marked out on either side of the central line, this breadth of 10 metres being sometimes increased to 15 or 20 metres if necessity arose. Along its length, the line was divided into 20-metre strips or sections. In these strips the following types were examined: storm-felled trees, logs, broken trees, slender tops with branches, and without, and stumps. Of each of these the following data were taken: length, middle diameter, degree of insect attack. The latter was expressed in percentages of actual bark-surface covered, i.e. single or 5 per cent., less than half, mean 25 per cent., half, 50 per cent., greater than half, mean 75 per cent., and 1, mean 95 per cent. In the case of stumps the length and diameter were recorded, and the degree to which their roots were broken off, representing the amount of their root-system still in touch with the soil.

The line thus surveyed, the 'production' of the most important bark-beetle species was then investigated. This involved the examination of pieces of bark, 20×40 cm., which were taken from all parts of the type of timber in question. These were broken up into small pieces and all larvae, pupae, young beetles, old beetles, exit-holes, parasites, predators, &c., counted. The numbers of the beetle's progeny were then estimated in relation to the egg-gallery, in terms of square metres of bark surface. Each of the 20-metre sections of the survey line was treated as a unit, and in each of these the bark-surface area of each item, i.e. logs, stumps, &c., was calculated as a percentage of the entire bark-surface, the whole bark-surface of the section being treated in the same manner. The production of the two important species was then calculated as a percentage of the available bark-surface, the production being assessed in all manner of varying types of breeding-place.

The records obtained as a result of the application of the linear survey method in the province of Uppland and other parts of Sweden were of the greatest interest and value. They enabled the forester to visualize in different regions exactly how the bark-beetle population was standing in point of numbers. Thus in Uppland, one area which had been partially cleared and was wholly surrounded by open country was surveyed. The strip measured 100 metres in length and constituted 16·25 per cent. of the total area of the damaged region. Here the strip recorded a total population of 512,000 *typographus*, equivalent to a population of 1,281,000 beetles per hectare. Similar data calculated for *piniperda* on 26·5 per cent. of the total area gave 319,600

adults per strip, or 220,000 per hectare. Figures such as these threw much light on the breeding-habits of the two species. Thus, *typographus* preferred the marginal areas of the devastated regions, near the standing trees, while *piniperda* chose the central portions. Further, *typographus* evidently increased more rapidly on smaller storm-holes (Hygge) which had only been partially cleared of timber than on larger ones which were still uncleared. On the other hand, *piniperda* rose to its maximum numbers on uncleared areas, decreasing rapidly as soon as clearing began, on account of the removal of the thicker-barked stems in which this beetle prefers to breed.

In addition to the great work involved in the making of the linear survey, extensive experiments on the preparation and use of trap-stems, methods of piling timber to protect it against insect attack, &c., were undertaken. The enormous mass of fallen timber necessitated that some method of stacking it in the forest itself should be discovered, and the experiments carried out in connexion with this showed that great differences existed between the two bark-beetles. It was shown that spruce timber could be piled in the forest and protected from *typographus* attack if covered with moss and faggots. Pine timber, on the other hand, could not be protected against *piniperda* in this manner, and was better left lying in the forest where it had fallen. The vast stock of firewood also was an obvious focus for bark-beetles to breed in, and other experiments were made as to the best method of obviating this. Here results showed that piling in the sunshine was better than piling under shade. Further, the wood must be cut as early in the year as possible to ensure as long a period for drying out as possible, and the consequent destruction of the beetle broods. The thickness of bark had, of course, a great influence in this respect. One other most important factor which was also studied in these experiments on the piling of logs was the incidence of the fungus (*Ceratostomella*) which causes the so-called 'blueing' of timber, and reduces its value by 20 or 25 per cent. in some cases. The attack of this fungus follows that of the beetles very closely, and one has seen pine stems in which the area attacked by the fungus corresponded exactly with that attacked by the bark-beetle.

It has been impossible in the space allotted to do more than touch briefly upon some of the more important points in this remarkable paper. Professor Trägårdh, summing up the main results, states that as a result of the prompt control measures taken by the Swedish Government in 1932 about 23 per cent. of the potential bark-beetle population was destroyed, a figure which, had further control been possible at the time, might have been greatly exceeded. The results showed also, however, that in 1934 there still remained a sufficient population of the spruce bark-beetle in Uppland to constitute a serious menace to the spruce in the vicinity of the devastated regions. A figure of some 3,000,000 spruce was quoted in this connexion. As a result of the evident value of the work which had been done, the Government continued to subsidize the Commission, and one looks forward with great interest to the possible publication in the future of an up-to-date record of the conditions as they exist in Uppland and other parts of Sweden to-day.

WORK IN POLAND.

We now pass to the third paper (3) mentioned in the introduction, which comes from Poland and is written by Dr. J. Karpinski of the Forest Research Institute of Warsaw. It bears the title, 'The Factors which limit the Reproduction of *Ips typographus* L., and *Ips duplicatus* Sahlb., in Virgin Forest'. It is selected for notice here because it deals with the important question of the part played by the natural enemies of bark-beetles in their control. In other words, it discusses the value of biological control, a subject which is gaining in importance as the years pass by. Some years ago Professor Munro, in an article entitled 'The Biological Control of Forest Insects' (4), expressed his views on this subject in the following words:

'Quite a number of injurious forest insects belong to the same biological group as the woodwasp [the *Sirex* woodwasp was under discussion in the article], and are dependent for their increase on special pathological conditions in the host. Bark-beetles, longicorn beetles, and woodborers may be said to belong to this group. As Escherich pointed out in 1912, the use of parasites to control such insects is wrong, because the major factor affecting their increase is not the absence of parasites, but the increase of the food supply. In this connexion he cites the failure to control bark-beetles in the Eastern States of America by the importation of the "Ant" beetle, *Thanasimus* (*Clerus*) *formicarius* L., from Europe. It seems probable, therefore, that in considering control by parasites in relation to forest insects, there is little prospect of success against insects belonging to this biological group. . . .'

This paragraph, if viewed in the light of a warning that once an outbreak of bark-beetles is on the way the forester must not expect natural control measures to step in and supersede the need for prompt artificial measures, expresses a view of the matter that most people who have considered the matter at all would be in complete agreement. It does not, however, tell the whole story. The study of the natural enemies of forest insects has not yet proceeded far enough in any region of the world to warrant the expression of any final opinion as to their efficacy in warding off attacks of bark-beetles or any other variety of wood-borer. The importation of the 'Ant' beetle into the States did not go far enough to prove anything either way. The study of these natural enemies and their host relationships is a very important one, especially in the case of the bark-beetles, and Professor Munro himself supplies the reason for its importance in the following passages: 'In biological control by parasites, as in all other methods of insect control, there is the closest relationship between the methods to be employed, and the methods of silviculture, and it is conceivable that in the application of control by parasites to forest insect problems, we may yet have to consider and investigate the whole question of the effect of silvicultural methods on the forest insect fauna. . . .' And again: 'In fact, it may be that the study of the control of forest insects by parasites, will lead to a fuller understanding of silviculture itself. . . .' In other words, applied to the study of the natural control of bark-beetles, the results obtained may effect most important changes in our methods of handling

thinnings, slash disposal, &c., so as to favour the population of natural enemies which forms such an important element of the forest fauna.

The paper just published by Dr. Karpinski is one of the most important contributions to this subject which has so far appeared. Dr. Karpinski has been engaged for some years in making a detailed study of the bark-beetle fauna of the Polish forest of Bialowies. In his previous papers he dealt with the whole bark-beetle fauna of the forest, which he discussed in relation to the various forest stand-types in which they were distributed. In the present paper he confines himself to the consideration of two species of spruce bark-beetles, *Ips typographus* L., and *Ips duplicatus* Sahlb. He takes as his main thesis the view that future control of such forest pests will be effected by the co-operation between the forester and those natural control agents present in the forest itself. He goes further, and states that artificial measures are bound to assume a secondary place. In other words, the forester of the future is, by making himself wise before the event, going to conduct his business so as to enable his natural allies to exert their utmost strength on his behalf.

This view is of great interest and importance, and demands that efforts be made to bring together large masses of relevant data to test its soundness. This is the author's main concern in the paper before us. Only a brief summary of the conclusions he has reached can be given here. For the study of details the reader is referred to the original paper, which contains a very lucid summary in French. The author recognizes the following natural factors as controlling agents of the two bark-beetles in question: (*a*) Overcrowding in the larval stage. Activities of small bark-beetles of the Genus *Crypturgus*, which make their galleries in the vicinity of those of the larger species, and in so doing destroy large numbers of their eggs. (*b*) Woodpeckers. (*c*) Insect predators and parasites. (*d*) Nematode worms, fungi, bacteria, protozoa.

The data bearing upon the activities of these different agents are gathered together in numerous graphs and tables which illustrate the work. They can be summarized as follows: taking all the factors together, they are shown to effect a reduction of 97·4 per cent. in the numbers of *typographus*, and 94·7 per cent. in those of *duplicatus*. Taking each group separately, interesting differences between the two species appear. Thus under (*a*) overcrowding accounts for only 17·6 per cent. in the case of *typographus*, and 60·9 per cent. *duplicatus*. Under (*b*) *typographus* shows a figure of 29 per cent., *duplicatus* only 8 per cent. Under (*c*) and (*d*) the author shows that he is fully alive to the difficulty of assessing the value of some of these factors. Clearly, insufficient data have been collected to warrant an individual assessment of each one, so he groups them all together, and assigns the figure of 50·8 per cent. for *typographus* and 25·1 per cent. for *duplicatus*.

His remarks on the activities of the various factors are of extreme interest. In discussing the fungi, for example, he is of the opinion that some of the non-parasitic species may be found to exert an important check on the beetle broods. Further details of work at present in progress are foreshadowed. He cites, in addition, a new form of the fungus *Beauveria* as a parasitic enemy of

value. Having presented his data, the author proceeds to show that it is in the power of the forester to translate theory into practice, by so manipulating his methods of thinning, barking, trapping, &c., as to encourage these natural factors to such purpose that they will exert a decisive influence on the bark-beetle population. He concludes his paper with the hope that his work will stimulate others to make further studies on these fundamental problems.

This paper forms, in our opinion, an interesting contrast to the previous ones. It discusses the subject of bark-beetle activities from a new angle. This aspect of the subject is of particular interest to British foresters, because in this country we are at present not faced with an actual bark-beetle outbreak, but we have at the same time a bark-beetle fauna in our forests which contains at least one major species, *M. piniperda*, and others which may, in the future, when our vast areas of coniferous plantations grow up, assert themselves as major pests.

The present study of the interrelations between these beetles and their natural enemies is of the greatest importance and value, and if it should be the case that practical methods of handling timber and slash can be evolved which will aid the natural increase of these controlling agents, ample effect will have been given to the possibilities envisaged by Professor Munro in the paper quoted above. The positive value of the natural enemies of the bark-beetles has not yet been finally assessed, but that they are a force to be seriously reckoned with should be apparent to those who study Dr. Karpinski's paper.

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RECENT WORK ON THE RELATION BETWEEN ANATOMICAL STRUCTURE AND MECHANICAL STRENGTH IN ENGLISH ASH

(*Fraxinus excelsior* L.)

BY S. H. CLARKE

(Forest Products Research Laboratory)

INTRODUCTION.

THE economic importance of ash depends to a greater extent than that of most timbers on its mechanical properties, particularly its exceptional toughness and high resistance to sudden impact. There is of course a wide variation in the properties of different pieces, some being comparatively weak and brittle ('brash'). It is of some importance, therefore, to investigate the factors which ultimately determine the strength of ash, in order to develop methods of estimating strength by inspection. This idea is, of course, not new; valuable empirical conclusions have been common knowledge for some time. Summarizing the more important points in 1917, Sterrett (4) wrote: 'The ashes follow the general law of timber in regard to the relations of the mechanical properties and weight; i.e., all the mechanical properties increase in force as the specific gravity of the wood increases. This is not, however, always a straight line relation.' It is a general rule for most species of the ash type that quickly growing trees produce timber of better quality than that of slowly growing trees, but 'trees grown under widely varying conditions . . . will probably show a large difference in rate of growth, with practically no difference in density or mechanical properties. . . . The toughest material appears to be at the butt, and the material strongest as a beam or upright is found higher in the tree . . . the best quality timber appears to be from 3 to 7 inches from the centre.' Sterrett concludes that in spite of all general rules regarding locality, rate of growth, and position in the tree, the specific gravity of the individual piece is usually the best indication of the probable mechanical strength.

The information yielded by specific gravity is, however, only partial, for wide variations in strength may accompany small ranges in specific gravity, and in recent years attempts have been made to explain these variations. Koehler (3) and his colleagues have investigated the causes of brashness and found this defect to be associated with adverse growth conditions, exceptionally low density, unusual obliquity in the slope of the cell-wall fibrils, the presence of high proportions of tissues other than mechanical tissues, or of compression wood; he also notes that decay, high temperatures, and treatments inducing compression failures are capable of producing a brash condition.

In this laboratory the problem of strength relations has been approached from a somewhat different angle, and it is interesting to note that the conclu-

sions reached agree with those of Koehler, namely, that strength is dependent on the physico-chemical nature of the cell-wall. This is particularly significant because in recent years investigators in various parts of the world have been driven to a closer study of the cell-wall in order to explain the physical properties of wood and other fibrous substances.

COMPRESSIVE STRENGTH.

(*a*) *Specific Gravity, Growth Rate, and Summerwood.*

The method followed in this laboratory has been to study individually the more important factors influencing strength. It is well known that within certain limits increases in specific gravity, ring width, and proportion of summerwood are accompanied by increases in strength. It is also known, however, that as ring width increases so do the proportion of summerwood and the specific gravity, and it is, therefore, necessary to decide how far each of these three factors actually influences strength, and to what extent, for instance, the strength–ring width relation is in reality a reflection of the strength–specific gravity relation. A study of maximum crushing strength in compression parallel to the grain (1) showed that this strength property does not depend directly on growth rate, but that the apparent relation of the two is probably a consequence of the relation between strength and the proportion of summerwood. It was also concluded that 'For any given specific gravity an increase in the proportion of summerwood in the annual ring is accompanied by a decrease in mechanical strength', this decrease probably being due to the decrease in fibre-wall thickness which must accompany any increase in summerwood at constant specific gravity. Viewing the situation from a slightly different angle, 'For any given proportion of summerwood in the annual ring, an increase in specific gravity is accompanied by an increase in mechanical strength that is due to an increase in the thickness of the fibre walls.'

Since the publication of the results described, material from five additional localities has been examined, and within each consignment the conclusions just stated were observed to hold.

(*b*) *Other Factors.*

The interrelation of strength, specific gravity, and summerwood observed within the limits of individual consignments was sometimes obscured when material from several localities was mixed. An illustration is provided in Diagram I, where it may be observed that each of seven consignments had a characteristic strength–specific gravity regression; the material of consignment 97, for instance, was about 1,000 lb. per square inch stronger than material *of equal specific gravity* from consignment 154. From this it is evident that the strength of ash may be influenced by one or more factors acting otherwise than through specific gravity, ring width, or the proportion of summerwood in the annual ring, and that sometimes these factors are associated with locality.

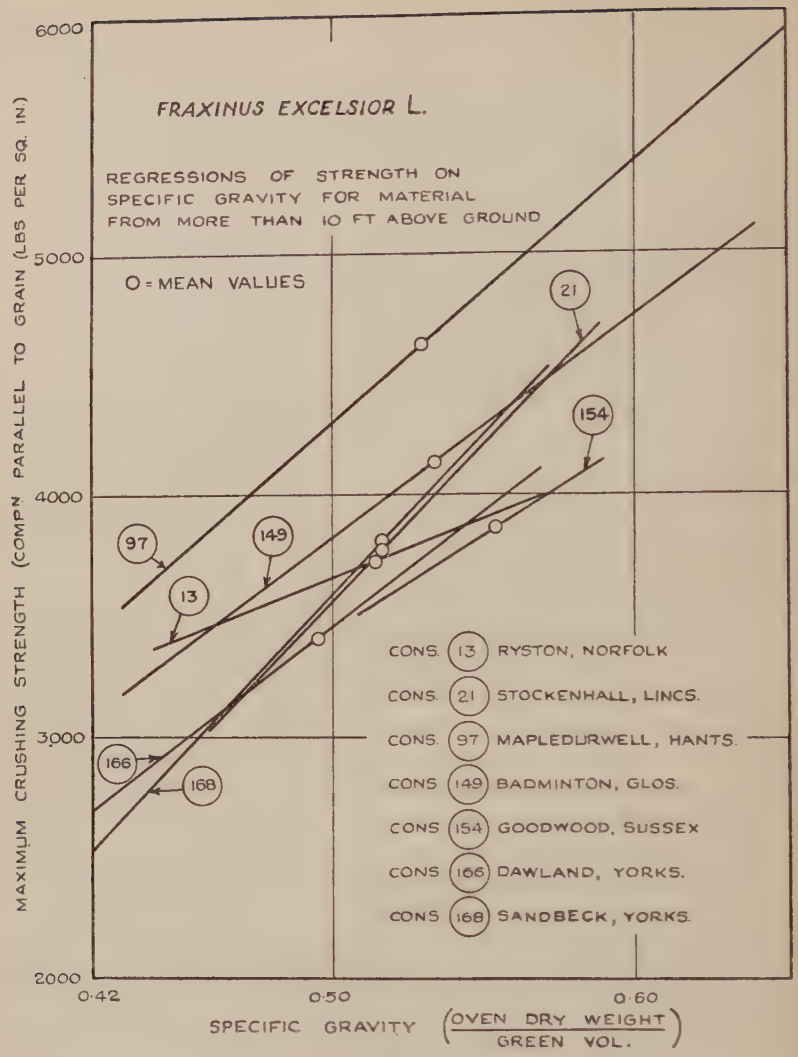

Diagram I.

In order to investigate these factors, it was decided to make a more intensive examination of selected test specimens closely resembling each other as regards specific gravity and growth rate, but differing widely in strength. For this purpose, fifty-four pairs of mechanical test specimens were selected from the material of six consignments, so that the individuals of each pair, although differing in maximum crushing strength by at least 1,000 lb. per square inch, were closely matched in respect of specific gravity, ring width, and summerwood proportions. A careful inspection of this material failed to provide any visually obvious reasons for the strength variations. From an examination of thin transverse sections mounted in gentian violet-glycerine jelly, it was

observed that in some pairs the secondary walls of the fibres of the strong specimens stained more deeply than those of the weaker ones. There were also somewhat vague differences in appearance between the cell-walls of strong and weak specimens as seen by polarized light, and it was accordingly decided to seek a reagent capable of differentiating between the members of the pairs.

Chlor-zinc-iodine, aniline sulphate, the Maüle reaction, and phloroglucin-hydrochloric acid[1] were tried, but only the last named was found capable of achieving the separation (2). In strong material, the walls of the vessels and parenchyma cells and the whole of the fibre walls stained red, the depth of colour varying from pink to crimson. In the weakest material the middle lamella region of the fibre walls stained a faint pink, the secondary walls remaining unstained; in these specimens too, however, the vessel and parenchyma cell-walls were deep crimson. Many intermediate stages were observed. On the evidence of these fifty-four pairs of specimens from six localities it was concluded that the phloroglucin test indicates variations in maximum crushing strength that are due to the influence of some factor connected with the physical or chemical nature of the cell-wall. In order to confirm this conclusion the test was applied to independent material from a new locality (consignment 168). About 150 specimens from four trees were tested in compression parallel to the grain by the Section of Timber Mechanics, and, before the strength figures were known, the phloroglucin test was applied to a transverse section of each specimen. From the staining reaction it was apparent that one tree (No. 62) contained stronger material than the other three, but that on the whole, taking specific gravity into account, three trees of this consignment would be classed as weak. It was, however, only possible to apply the phloroglucin reaction in a roughly quantitative manner by comparing the general colour reaction of the consignment as a whole with the reaction of other consignments tested previously. A series of curves for estimating strength (1, page 30) was then constructed, using data obtained from the previously tested material most closely resembling the consignment in question (No. 168). By using a single set of curves for the whole of the new consignment, it was expected that the strength of the specimens from tree 62 would be under-estimated. In Diagram 2 estimated and tested strengths are compared, and it may be seen that in trees 60 and 63, agreement is good, in 61 it is fair, whereas in 62, as expected, the strength was under-estimated.

The anomalous behaviour of tree 62 as compared with other trees of the consignment suggests that the influence of the factor concerned is not solely that of an ecological factor operating more or less uniformly over a fairly wide locality. Moreover, it was found that the intensity of the phloroglucin reaction

[1] Prepared by heating 1·1 gm. of phloroglucin crystals in 30 c.c. concentrated hydrochloric acid and diluting to 150 c.c. Sections were removed from 97 per cent. alcohol to a clean slide, the alcohol blotted away and one drop of phloroglucin-hydrochloric acid added. After about 30 seconds a drop of concentrated hydrochloric acid was added and a coverslip placed over the preparation. It is essential for comparative purposes that sections should be of uniform and standard thickness; in the present instance, 10 microns was found to be a convenient thickness.

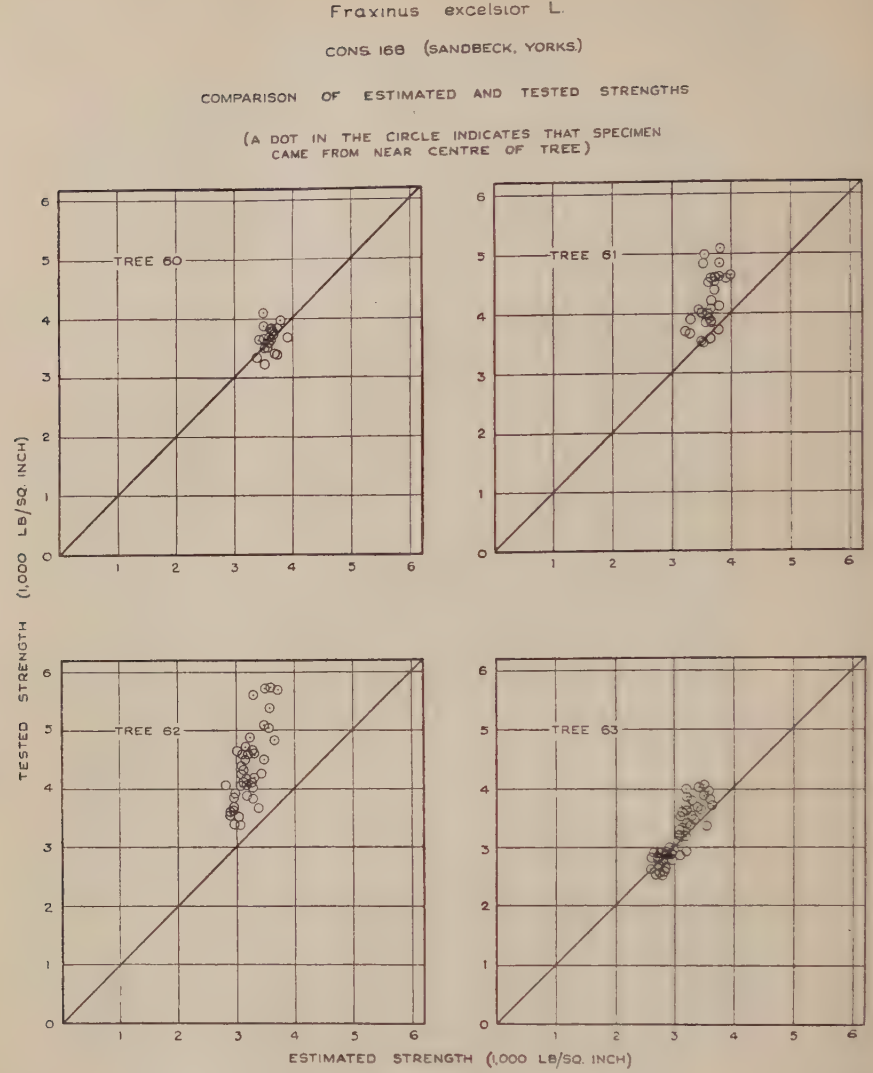
Fraxinus excelsior L.
CONS. 168 (SANDBECK, YORKS.)
COMPARISON OF ESTIMATED AND TESTED STRENGTHS
(A DOT IN THE CIRCLE INDICATES THAT SPECIMEN CAME FROM NEAR CENTRE OF TREE)
TREE 60
TREE 61
TREE 62
TREE 63
TESTED STRENGTH (1,000 LB/SQ. INCH)
ESTIMATED STRENGTH (1,000 LB/SQ. INCH)

Diagram II.

sometimes varied within individual trees. The variation of the reaction intensity within individual trees was not great, however, and although occasional trees differed considerably in behaviour from others of the same consignment, there was a distinct tendency for trees of a single locality to react similarly.

TOUGHNESS.

Since material from near the butt is found to be strongest in toughness, whereas material from higher in the bole is stronger in compressive strength (4), it may be inferred that toughness and strength in compression differ in the extent to which they are related to specific gravity and other properties.

These conclusions of Sterrett have been confirmed by investigations so far carried out at this laboratory, and it may be stated that whereas specific gravity, ring width, and the proportion of summerwood in the rings are all related directly or indirectly to toughness, the relations are not so close as those between these three features and strength in compression, and it is evident that some other factor influences toughness to a more important degree.

Following the line developed in the study of strength in compression, a number of pairs of test pieces was selected, the members of each pair being carefully matched for specific gravity, ring width, and percentage of summerwood, but differing markedly in toughness. Phloroglucin-hydrochloric acid and cuprammonia[1] both proved unsatisfactory in attempts to differentiate between the members of the pairs, and various other reagents were tried with similar lack of success. A possible reason for this is suggested by examination of the cross-sections of splinters from the zones of failure of toughness test pieces from normal wood (Plate XIII, figs. 3–10). Here it may be seen that in practically every case failure has occurred between the primary and secondary walls of the fibres, or across the primary wall and middle lamella (as at *a* in Plate XIII); the secondary wall is broken in the case of vessels and parenchyma cells, but comparatively rarely in the fibres (as at *b* in Plate XIII, figs. 6 and 8). Under compression parallel to the grain, however, the initial failures, in the form of minute 'slip planes', occur in the secondary walls of the fibres (Plate XIII, fig. 2). It is therefore easily understood that although certain staining reactions of the secondary wall supply information with regard to strength in compression, they do not appear to be of equal value as indicators of toughness. In further investigations attention is being focused on the region where failure actually occurs.

DISCUSSION.

During the last few years, considerable attention has been given to studies of the physical and chemical nature of the cell-wall. In various parts of the world the realization seems to have been forced upon investigators that it is from the fine structure of the cell-wall that explanations of peculiarities in the physical properties of plant fibres are to be expected.

Experience has shown that although specific gravity, growth rate, and proportion of summerwood in the rings are all useful as direct or indirect indicators of strength, there are many occasions on which the information they yield is insufficient, and many samples are found to be inexplicably weak or strong. Comparison of ash timber from seven localities has shown that certain factors exert an influence which is superimposed on those already named, and which is probably of primary importance in determining strength. In the case of strength in compression, the evidence of the phloroglucin reaction suggests that the secondary walls of the fibres form the principal seat of influence of these factors. In the case of toughness, on the other hand, the lack of corre-

[1] Professor S. E. Wilson, after reading the note in *Nature* (2), kindly wrote suggesting the use of cuprammonia, a reagent he had found successful in the past in certain work on ash. Unfortunately it was not satisfactory in the present instance.

lation between the results of staining reactions of the secondary walls and variations in strength, and the fact that, in normal wood, failure of the fibre wall takes place by separation of the primary and secondary walls and by rupture of the middle lamella, suggest that this type of strength depends less on the properties of the secondary wall than on the nature of the primary wall and the middle lamella. Such a condition would also explain why strength in compression is usually more closely related to specific gravity than is toughness, because the secondary walls of the fibres usually account for the bulk of the weight of the wood of ash.

Besides being of interest in that they take us a step nearer to understanding the strength variations of wood, these conclusions may prove of value in subsequent work of an ecological character. Among problems still requiring attention are the factors which determine the distribution of the wood substance in the woody tissue of the annual ring, in particular, for example, those which determine that a tree shall produce a certain number of thick-walled fibres rather than a larger number of thinner walled fibres.

SUMMARY.

1. The relative importance and the nature of the influence of certain factors supposed to affect the strength of wood are discussed.

2. It is shown that the physico-chemical nature of the cell-wall is of great importance in determining mechanical strength.

3. Differences in behaviour of strength in compression and toughness are noted, and it is suggested that the former is closely linked with the secondary wall of the wood fibres, whereas the latter depends rather on the primary wall and middle lamella.

ACKNOWLEDGEMENTS.

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EXPLANATION OF PLATE XIII

Fig. 1. Tangential section (× 240) of normal wood by polarized light.

Fig. 2. Tangential section (× 240) near failure in compression, by polarized light, to show slip planes in secondary walls of fibres.

Figs. 3–10. Tranverse sections (× 200) of splinters from toughness failures, showing separation of fibres, by ordinary transmitted light.

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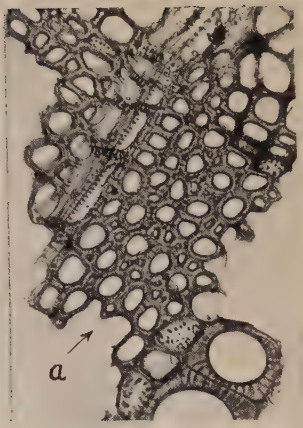

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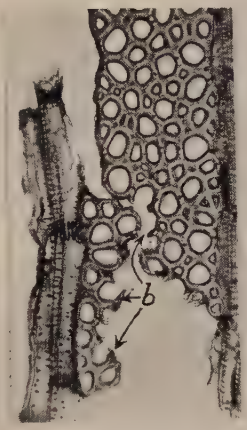

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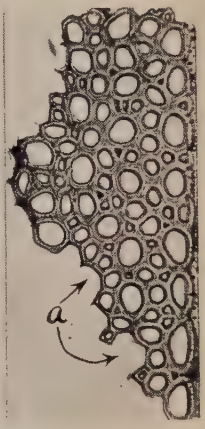

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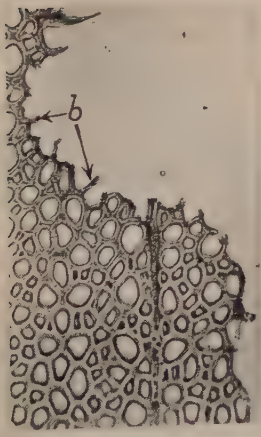

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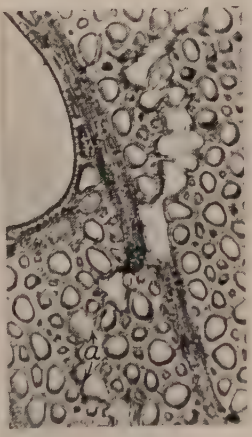

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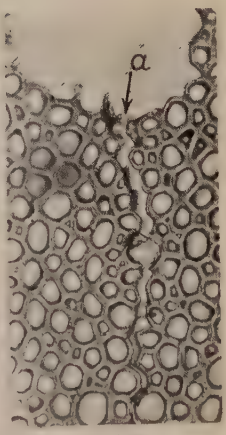

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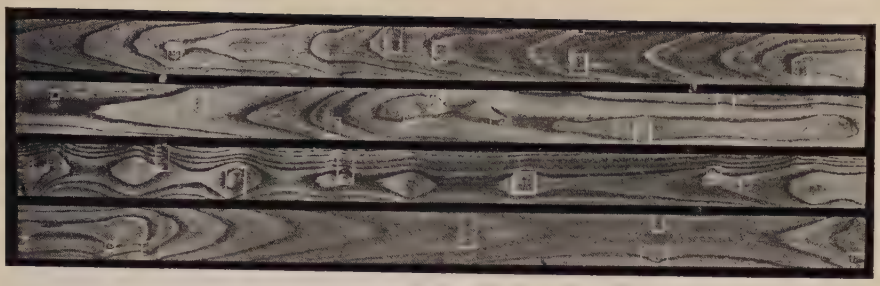
Photomicrographs of *Fraxinus excelsior L.*

PLATE XIII

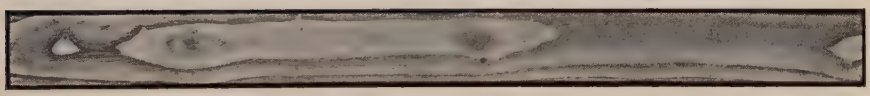


1. Typical bending planks. Pin-knots marked with squares

a

b

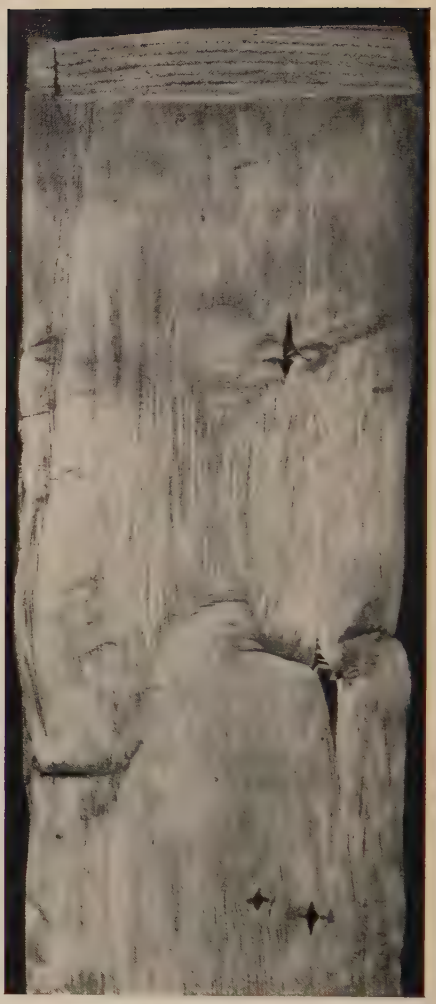
2. *a*. Bend containing knots
b. Bend free of knots



3. Specimen *a* before bending

PLATE XIV

4. Enlarged end of specimen *a* before bending



5. Enlarged end of specimen *a* after bending

PLATE XV

THE EFFECT OF PIN-KNOTS ON THE BENDING OF TIMBER ILLUSTRATED FROM SWEET CHESTNUT

BY W. C. STEVENS

(Forest Products Research Laboratory, Princes Risborough)

IT has long been recognized that the presence of pin-knots in ash lowers the value of the timber for bending purposes, if not prohibiting its use altogether. The present note shows how this also may apply to other timbers whose properties otherwise make them good bending timbers. It brings out the importance of silvicultural care in all stages of the crop if timber of bending quality is aimed at in the final crop.

A special point to be noticed is that virtually no pin-knot, no matter how small, can be said to be harmless.

A consignment of sweet chestnut was converted into approximately 300 pieces, 3×2 inches and $3 \times 1\frac{1}{2}$ inches in cross-section; it was sawn with the growth rings running in the general direction of the broad faces, as this has been found to be the best method of conversion for bending.

The timber was of excellent quality except for the presence of a number of pin-knots. Plate XIV, fig. No. 1 shows typical specimens, the knots being marked by a square. Only 3 per cent. of the pieces were free from such knots.

For ordinary straight work the knots would not have been regarded as a defect, but it was found quite impossible to make a successful bend from any knotted piece.

The samples were bent to a semicircle of 8-inch radius, after the most suitable method of treatment as to steaming and end pressures had been ascertained by preliminary test. The few pieces free from knots bent with relative ease and without fault, but in every case the knotted pieces failed to produce a good bend. The timber was bent first in the green condition, and the general failure was thought to be partly due to the amount of moisture in the wood. When it was found that air-dried timber failed in a similar way, the experiment was stopped.

The defect took the form of a severe local bursting or splitting at each knot on the inner face of the bend, and this was accompanied in many cases by a less local buckling of the inner surface and the edges of the bend.

Plate XIV, fig. No. 2 shows two bends, one of knotted and one of clear timber. Both were released before photographing after being bent to a full semicircle. Plate XIV, fig. No. 3 and Plate XV, figs. Nos. 4 and 5 show a typical specimen, with enlarged views of one end before and after bending.

The experiment was carried further by cutting a few specimens with rings running at right angles to the broad faces, so that the knots emerged on the edges rather than the faces of the bends. These all failed, however, through heavy local buckling on the inner face along the line of the knot. A few clear pieces cut in this way bent without blemish.

THE FOURTH BRITISH EMPIRE FORESTRY CONFERENCE

South Africa, 1935

BY W. H. GUILLEBAUD

AS a delegate to the fourth British Empire Forestry Conference held in South Africa in September 1935, the writer has been asked to give some account of the proceedings of the Conference and of the work accomplished. Before doing so it may be as well to review briefly the previous history of the Empire Forestry Conferences. The first of these was held in London in the year 1920, almost immediately after the creation of the British Forestry Commission. Under Sir Francis Acland as Chairman, this London Conference laid down the broad lines on which future meetings should proceed, the basic principles of forest policy were enunciated, and a first attempt was made to arrive at the position within the Empire as regards supplies of merchantable timber, quantities consumed, volumes and values of exports and imports, and so on. Other matters dealt with in the Resolutions of the first Conference concerned research, education, terminology and trade nomenclature, contact with organizations of forest industries, publicity, &c.

It was decided in London that future conferences should be held in different parts of the Empire, and that, in addition to reviewing and strengthening as far as possible the position of forestry in the Empire as a whole, special attention should be given to the specific forestry problems of the country in which the Conference was being held. The second Conference was accordingly held in Canada in 1923, with Lord Lovat as Chairman. The tours through different parts of the Dominion brought home to the delegates the fearful destruction due to forest fires, and the publicity given to this matter as a result of the proceedings and resolutions of the Conference gave much needed support to the forest departments of the Dominion. As a consequence, the Canadian delegates to the South African Conference were able to report excellent progress in the conservation of their forest estate from fire.

The third Forestry Conference visited Australia and New Zealand in 1928, and under the guidance of Lord Clinton gave much time and thought to the special problems of those countries. Perhaps the chief feature in Australia was the excessive utilization going on in the Eucalypt forests. Here the rate of felling far exceeded the current increment, and all efforts on the part of the forestry services to check this state of affairs had proved unavailing. Once again the influence of the Empire Forestry Conference made itself felt, though unquestionably the major influence was that of the financial depression which put many of the saw-mills out of business and so relieved the pressure on the forests. In New Zealand, where afforestation with fast-growing conifers had been proceeding on a huge scale for some years past, an obvious problem con-

fronting the forest service was that of the silvicultural treatment of the young plantations, more especially as regards thinning. It is much to be regretted that New Zealand failed to send a delegate to the South African Conference, while from other sources it appears that the forestry position in that Dominion is far from satisfactory.

The Conference which has recently concluded assembled at Durban on 2 September 1935. Sir Roy Robinson, Chairman of the Forestry Commissioners, was elected Chairman of the Conference, and Mr. J. D. Keet, Chief of the Division of Forest Management of the Union, was elected Vice-Chairman. A new and useful precedent was started on this occasion by the election of a President and Vice-President to the Conference from the country in which the delegates were meeting, the former was Colonel Denys Reitz, Minister of Agriculture in the Union, and the latter Dr. P. R. Viljoen, Permanent Secretary to the Ministry of Agriculture and Forestry.

This may be a convenient place at which to refer briefly to the organization of the Forestry Service of the Union. Since the retirement in 1931 of Mr. C. E. Legat, formerly Director of Forestry in South Africa, the Service passed through a difficult period. In 1934, as a measure of reorganization, it was decided by the Government to place it under the Ministry of Agriculture, of which department it formed a separate division of equal status with other divisions such as those of Plant Industry, Veterinary Science, &c. Although the deprivation of its independent status must have been, and was in fact, regarded by the Forestry Service as somewhat of a blow to its prestige, under the able and tactful administration of the Permanent Secretary, Dr. Viljoen, the Service was successfully reorganized and the delegates to the Conference were impressed by the vitality and *esprit de corps* that pervaded the Division.

To return to the proceedings of the Conference, at the opening session held at Durban, Colonel Reitz, the newly elected President of the Conference, speaking on behalf of the Union Government, requested the delegates to examine the whole question of afforestation in relation to water supply. He explained that there was a strong movement in many parts of the country which was hostile to afforestation on account of the supposed adverse effects of the plantations on local water supplies. Complaints were being received from numerous sources to the effect that springs were failing and watercourses drying up as a result of the activities of the forestry department. The pressure in fact was so strong that it had become a political issue of almost major importance. Other counts in the indictment were that the plantations were encouraging rather than checking erosion, that rectangular blocks of pure conifer formed ugly blots on the landscape, and that the wild flowers, which are the peculiar beauty of the veld, were being wantonly blotted out. As a result of Colonel Reitz's request a strong Committee was appointed, with Mr. C. G. Trevor, Inspector-General of Forests in India, as Chairman. This Committee, which was termed the Forest Influences Committee, was instructed to report on the influence of forests upon various climatic factors such as rainfall, evaporation, atmospheric humidity, &c., upon water conservation and

upon erosion. A further task was also imposed upon the Committee at the special request of Colonel Reitz, namely, to express their views upon the much debated question of veld burning, with special reference to its relation to soil erosion.

Other committees appointed by the Conference were those on timber supplies, consumption, and marketing, on forest products research, on silviculture, and on the Imperial Forestry Institute.

The membership of these committees was as follows:

Forest Influences

C. G. Trevor	India (Chairman)
J. R. Ainslie	Nigeria
W. F. Baldock	Tanganyika
N. U. Brasnett	Uganda
E. H. Finlayson	Canada
A. V. Galbraith	Victoria
J. D. Keet	South Africa
A. O'Connor	South Africa
R. W. Thornton	South Africa

Timber Supplies, Consumption, and Marketing

T. A. McElhanney	Canada (Chairman)
I. H. Boas	Australia
P. Z. Caverhill	British Columbia
C. J. Chaplin	Great Britain
N. B. Eckbo	South Africa
A. E. Heath	Australia
A. P. Long	Great Britain
F. M. Oliphant	Great Britain
J. N. Oliphant	Federated Malay States
A. R. Villar	India

Forest Products Research

N. B. Eckbo	South Africa (Chairman)
I. H. Boas	Australia
C. J. Chaplin	Great Britain
J. E. Kaufmann	South Africa
T. A. McElhanney	Canada
F. M. Oliphant	Great Britain
J. N. Oliphant	Federated Malay States

Silviculture

C. E. Lane-Poole	Australia (Chairman)
I. J. Craib	South Africa
H. M. Gardner	Kenya
E. A. Garland	India
W. H. Guillebaud	Great Britain
L. S. Hudson	New South Wales
S. L. Kessell	Western Australia
N. L. King	South Africa
J. J. Kotze	South Africa
F. S. Laughton	South Africa

Imperial Forestry Institute

C. G. Trevor	India (Chairman)
E. H. Finlayson	Canada
R. D. Furse	Great Britain
W. H. Guillebaud	Great Britain
J. D. Keet	South Africa
C. E. Lane-Poole	Australia

The reports of the several committees can be briefly summarized as follows:

1. FOREST INFLUENCES.

After referring to the well-known effects of forests in modifying such climatic factors as wind, extremes of heat and cold, in reducing evaporation from the surface of the soil and increasing atmospheric humidity, the Committee discussed the relation between forests and rainfall. It considered that while there was ample evidence to show that forests have a favourable influence upon the local distribution of rainfall, there was none to justify the view that forests have an appreciable effect upon the general rainfall of a country. As regards water conservation, the balance of evidence was considered to be strongly in

favour of the forest which increases the absorption capacity of the soil and checks run-off, so reducing the silting up of dams and reservoirs. Owing to lack of the necessary observational data the Committee was unable to make any definite pronouncement on the effect on river sources and springs of planting exotic species, more particularly gums and wattles, round these sources. It considered it to be unlikely that such planting would be detrimental to stream-flow, but considered it advisable, pending a comprehensive investigation of the whole matter, to defer to public opinion and refrain meanwhile from afforesting areas of vital importance from the point of view of water supply. In such areas the natural veld vegetation should be carefully protected from excessive burning or grazing. The report then proceeds to deal with the crucial question of erosion, one of the most acute problems to-day in Africa as well as in many other parts of the world. Erosion, the report states, results from the misuse by man of the surface covering of the earth, whether it be by the destruction of the forest or by the misuse of pasture land by bad methods of cultivation, burning, or overgrazing. Of these agents deforestation must certainly rank as one of the most important; in the low rainfall savannah country of Africa destruction of the forest by fire has proceeded at an alarming rate and in such regions as Northern Nigeria is reducing large areas to a state of desert. The remedies for erosion are given as the protection of the soil from burning and grazing, engineering works to check gullying, and the afforestation of water-catchment areas. The charges made by some South Africans to the effect that wattles and eucalypts promote erosion were considered to be wholly without foundation.

In the concluding section of the report some observations are made on the subject of veld burning. The general practice in South Africa is to burn a large proportion of the veld every year or so; the fires are usually started in the dry weather and produce a fierce type of burn from which the vegetation is slow to recover when the rains come, while the regrowth is of too limited duration for satisfactory grazing. Gradually the evil effects become more pronounced, and the final result is a surface which is unable to offer any resistance to the process of erosion. The report recommends the introduction of the system of controlled burning which is proving so successful in Northern Nigeria and elsewhere. Essentially this consists in running a light fire over the ground which will remove the dead grass and other unwanted cover but will leave the roots intact and ready to respond to the first onset of the rainy season.

The Conference, having considered the report of the Committee on Forest Influences, passed the following Resolution:

'The Conference approves the Report of the Committee on Forests in Relation to Climate, Water Conservation, and Erosion.

'In view of the important and beneficial influence of forests on Water Conservation, on Soil Erosion, and on the maintenance of equable climatic conditions, the Conference urges on the Governments of the Empire the necessity of maintaining under forest cover catchment areas and lands particularly liable to erosion or desiccation.

'The Conference also urges the i mportance of scientific investigation of all aspects

of the subject, both in South Africa and in other parts of the Empire, and recommends that a copy of the Committee's report and its enclosures be submitted for the special consideration of the Government of the Union of South Africa.'

2. REPORT OF THE COMMITTEE ON TIMBER SUPPLIES, CONSUMPTION, AND MARKETING.

One of the principal duties of this Committee was to summarize the data relating to forest resources, increment, exports and imports, &c., which were given in the statements prepared for the 1935 Conference by almost all the forest authorities throughout the Empire. The Committee gave a great deal of time and effort in an attempt to compile a satisfactory summary, but found the task impracticable on account of the incompleteness of the information submitted and the lack of uniformity in the methods adopted in compiling statements. However, the effort was not wholly in vain because the Committee was able to put forward suggestions for improving the form in which statements are to be rendered in future, and it is hoped that the next Conference will find the data capable of analysis.

Dealing with the use of Empire timbers within the Empire, the report points out that though trading in timber in foreign markets has become increasingly difficult during the past five years, timber trade in the Empire has showed marked advances. The recommendation is made that governments and other public bodies should specify Empire timbers in their building programmes wherever economically practicable.

The next subject discussed, that of the utilization of thinnings, is considered to fall into two parts: (1) the finding of new markets for all sizes and grades of thinnings, and (2) the discovery of uses capable of absorbing the ever-increasing supplies of raw materials. There are local markets such as pitwood which are of great importance in some countries, e.g. Great Britain and South Africa, and more general uses, among which the report mentions wood pulp, fencing material, rough construction, charcoal, poles of all sorts, small sawn timber, and fuel. In South Africa some interesting portable mills were visited in which the whole utilization depended on thinnings which varied from a maximum of about 10 inches to a minimum of 5 inches diameter at the butt.

Trade names of Empire timbers and the question of making a central timber exhibit in London are the subjects dealt with in the concluding sections of the report. As regards the former, various recommendations are made for the guidance of the institutions engaged in revising the list of trade names already published, while as regards the latter the Committee make no definite recommendations on the proposal. The following Resolution was passed by the Conference:

'The Conference approves the Report of the Committee on Timber Supply, Consumption, and Marketing.

'(*a*) *Increased Use of Empire Timbers.*

'The Conference notes with satisfaction the substantial increase since the previous Conference in inter-Empire timber trade and also the possibilities of further expansion.

'The Conference urges Governments and public bodies within the Empire to specify Empire woods for their works as far as is economically practicable.

'(*b*) *Trade Names of Empire Timbers.*

'The Conference notes the increasing confusion which is caused by the undesirable practice of using established names of timbers in connexion with other timbers of unrelated species. It approves the steps which have already been taken by the Empire Forestry Association, the Imperial Institution, and the British Standards Institute, in preparing lists of standard names, and thanks them for the work done. The Conference requests them to revise, from time to time, the lists on the lines laid down in the Report of the Committee.'

3. REPORT OF THE COMMITTEE ON FOREST PRODUCTS RESEARCH.

The Report lays stress on the importance of closer co-operation between forest products laboratories, the chief of which are Princes Risborough, Ottawa, and Melbourne, within the British Empire, and Madison in the U.S.A. In particular the need is expressed for a more complete standardization of methods of testing. Other points brought out in the Report are: (1) the desirability that all forest products laboratories within the Empire should interchange their yearly programmes of work and also their annual reports; (2) that there should be greater facilities for the interchange of research officers between laboratories; (3) co-ordination of research to prevent unnecessary overlapping; (4) a sub-committee of the Standing Committee of the Conference should be set up to maintain close touch between the laboratories and to promote as far as possible co-operation and the standardization of methods.

The Resolution passed by the Conference reads as follows:

'The Conference approves the report of the Committee. It draws attention to the advantages which should accrue from the exchange of officers and closer co-operation between Forest Products laboratories, particularly in connexion with standardization of methods and the prevention of duplication of effort. With these objects in view, the Standing Committee of the Conference is requested to set up a sub-committee to deal with the proposals contained in the Committee's report.'

4. IMPERIAL FORESTRY INSTITUTE.

The chief conclusions of the Committee were:

(1) That the Imperial Forestry Institute can, if properly organized and given adequate financial support, play a most useful part as a centre of post-graduate training in forestry for the whole Empire.

(2) The teaching of forestry in all its branches and on the broadest possible lines should be the first care of the Institute, particularly in the case of serving officers sent to it for instruction from overseas.

(3) There should be much closer contact between the staff of the Institute and the forest services of the Empire.

(4) In addition to its functions in training forest officers the Institute should concern itself actively in the collection and dissemination of information, and in the production of abstracts of forest literature and their circulation through-

out the forest services of the Empire. A special division of the Institute should be organized for this purpose.

(5) As to finance: in view of the fact that agreement has been reached with Oxford University as to the constitutional position of the Institute, and that the University has offered an admirable site free of charge provided that building can be commenced reasonably soon, every effort should be made to place the Institute's finances on a more satisfactory footing. An additional income of £5,000 per annum guaranteed for five years is required to enable the Institute to function properly, and it is hoped that this will be raised.

The Resolution passed by the Conference commended the Report for consideration by all Governments of the Empire.

5. SILVICULTURE.

The work of the Committee on silviculture was naturally based to a great extent upon the local problems encountered during the course of the Conference tours. Of these perhaps the most outstanding was the silvicultural treatment of the plantations of pines which form the bulk of the new forest areas created during the last 20 years in the Union. The Conference had before it an interesting paper by Dr. I. J. Craib of the South African Forestry Division, in which he showed that the wattles (*Acacia mollissima* and *A. decurrens*) are so intolerant of mutual competition that any failure to give them adequate growing space, from the earliest years onwards, results in much retarded development both in height and diameter. Once the crowns have become appressed the trees fail to make any adequate response to thinning and merely stagnate. If, however, thinning proceeds on the basis of anticipating competition rather than of relieving it, the trees develop a full vigorous crown, and production, both of bark and timber, is greatly increased as compared with the method of treatment hitherto in vogue. Arguing from the premisses of his work on the wattles, Dr. Craib suggested that the same methods would be applicable to plantations of such fast-growing species as *Pinus patula* and *P. radiata*. The following thinning schedule will illustrate the treatment proposed. Starting off with an initial spacing of 7 feet, i.e. 890 trees per acre, a first thinning to 400 stems per acre would be made immediately the trees have formed canopy, on good sites this would be at about 5 to 6 years after planting. When the average breast-height diameter reaches 5 inches—at about 10 years—half of the stems would be removed, and of these 100 selected stems would be pruned to a height of 7 feet. The next and final thinning, removing the 100 unpruned trees, would take place when the average diameter reaches 8 to 9 inches, and pruning is to proceed until there is a clean bole of 30 feet in length with a knotty central core of not more than 6 inches in diameter. It is anticipated that the rotation would be about 30 to 35 years, when the final crop should have an average diameter of about 30 inches at breast height. It will be observed that this implies an average ring width of about ½ inch, and in its Report the Committee points to the lack of evidence as to the marketability of such fast-grown timber. The recommendation is made that in addition to

establishing sample plots to test the reaction of a wide range of species and sites to such treatment, provision should also be made for a continuous mill-production test over a period of years. The latter would involve the selection and treatment of a considerable area of plantation on a good site and in a suitable locality.

In addition to the discussion of this question of the heavy early thinning of the fast-growing species of pine, the Report of the Committee contains a short summary of silvicultural practice throughout the Empire, as applied to afforestation, and also singles out for special mention those aspects of silviculture in South Africa which appeared most noteworthy. These include choice of species, nursery practice, preparation of ground for planting and subsequent cultivation, thinning practice, and treatment of indigenous forests. As these are the points which are likely to be of interest to the general reader, the writer proposes to discuss them in some detail.

Owing to the lack of indigenous coniferous species suitable for large-scale afforestation the South African foresters have had to rely entirely upon exotic species for their new operations. After thorough investigation in other countries having approximately similar climatic conditions and the establishment of arboreta in different parts of South Africa, a number of species have now come into general use for extensive planting. Before detailing these some reference to the special climatic conditions in the Union is necessary. The country can be divided roughly into three climatic zones according to the distribution of the rainfall, namely, the zones of summer rainfall, winter rainfall, and constant rainfall respectively. Of these the first occupies the greater part of the Union, the winter rainfall zone is confined to a belt in the south-west of the Cape Province, including Capetown, while the third zone, in which the rainfall is distributed fairly uniformly over the whole year, forms a small coastal belt between Mossel Bay and Port Elizabeth, also in Cape Province. Within each of these zones the amount of rainfall varies from a minimum of 10 to 15 inches and a maximum of 70 to 90 inches per annum. The drier parts of the country, where the rainfall is below 25 to 30 inches per annum, are not considered suitable for large-scale afforestation, and the greater part of the new plantations are distributed along the mountain ranges in the northern and eastern Transvaal, in Natal and in the south of the Cape Province. As might be expected, the tree species employed vary according to the seasonal distribution of the rainfall. To quote from the Report:

'The following coniferous species are now employed for large-scale afforestation in South Africa:

	Species.	*Country of Origin.*
Summer Rainfall Areas.	*Pinus patula*	Mexico
	Pinus taeda	South-east U.S.A.
	Pinus caribaea	„ „
	Pinus longifolia	Northern India
Winter and Constant Rainfall Areas.	*Pinus pinaster*	Southern Europe
	Pinus radiata (*insignis*)	California

Cupressus lusitanica, a native of Mexico, is being planted to some extent in the summer rainfall zone, while *Pinus taeda* and *P. caribaea* are promising in the zone of constant rainfall.

'Certain species of Eucalypts have been employed extensively in the past for afforestation, but recently the policy has been to restrict their use to the formation of protective belts in coniferous plantations. The principal species used for these belts in the summer rainfall zone include *Eucalyptus grandis*, *E. saligna*, *E. paniculata* and *E. fastigata*, all eastern Australian species; *E. diversicolor*, a native of West Australia is planted in the winter and constant rainfall zones, while *E. cladocalyx* from South Australia is used in the winter rainfall zone only.'

Various Australian species of Acacia have been successfully employed in the native reserve of the Transkei for the production of timber fuel to meet local requirements, and also for drift-sand reclamation along the southern coast of the Cape Province.

Taken as a whole, the choice of species appears to have been remarkably successful. Particularly in the summer rainfall zone, e.g. in the northern and eastern Transvaal, the flourishing state of the pine plantations and their virtual freedom from fungus attack or insect pests leave little to be desired. The locust is perhaps the most serious nuisance in the pine plantations, but this is a universal pest which the forest shares equally with the surrounding farm lands. Broadly speaking, the tendency is to plant such species as *Pinus patula*, *P. taeda*, and *P. caribaea* only on the better soils in the summer rainfall zone, *P. longifolia* replacing them on the poorer sites. In the winter rainfall areas of the Cape Province *Pinus radiata* is now confined strictly to the good localities, leaving *P. pinaster* as the principal species for planting on average and poor sites. The one outstanding case of faulty selection of species encountered during the tour, was in the district of George, near Mossel Bay in Cape Province. Here *Pinus radiata* had been planted on shallow leached soils, often with a thin layer of peat. The trees grew well for the first few years but then became unhealthy, the tips of the side branches dying back, with the result that a remarkably narrow, spire-like type of crown has developed. On the worst sites considerable areas of *P. insignis* have died out altogether. Some of these poor areas are to be abandoned and others heavily thinned and under-planted with maritime pine.

The nursery practice employed almost universally in South Africa is interesting alike for its simplicity and the certainty of results. Typically the method consists in sowing the seed in prepared soil in wooden boxes $14 \times 10 \times 5$ inches (formerly 4-gallon petrol-tins cut in two were used). Two to three months after germination the seedlings are pricked out into other boxes at the rate of 25 to 30 seedlings per box, and are usually ready for planting out at the end of a further period of from 4 to 6 months. By this time the plants are about 6 inches high and very sturdy. The boxes are of course kept regularly watered and are also shaded when necessary, as, for example, immediately after pricking out. A great deal of care is given to the composition of the soil mixture employed in the trays: a sand or very light sandy loam is always employed as the

basis and top soil only used for the purpose; if this is deficient in humus, up to 20 to 25 per cent. by bulk of organic matter is added as well as a certain amount of the top soil collected from a near-by conifer plantation to ensure the presence of the necessary mycorrhizal fungi. Superphosphate or basic slag is often applied to the mixture, and if the soil appears deficient in available nitrogen top dressings of a dilute solution of some nitrogenous fertilizer may be given. In practice there appears to be little or no difficulty in finding a suitable soil mixture for filling the boxes, nor has the raising of plants to provide for a planting programme of up to 2,000 acres in a single forest and year presented any serious problem. In discussion with South African foresters the writer found them to be agreed on the greater survival value in the forest of plants with strong shoots. Root-shoot balance appears to be of secondary consequence; the most successful plants are those with the best-developed shoots. It should be observed, however, that the practice of pricking out, or, alternatively of sowing at the low density of 40 seeds per tray where the seedlings are to be used for direct planting, prevents any possibility of overcrowding, each plant having room for free development.

Preparation of Ground for Planting and Subsequent Cultivation.

With comparatively rare exceptions it has been the practice in South Africa to cultivate thoroughly the ground before planting. The land is first completely ploughed, then cross ploughed, and finally harrowed. If the ground is unsuitable for ploughing it is, or was until quite recently, completely hand picked. When the planting season opens the boxes are transported on to the area; each plant is removed from the box with a trowel so that there is a cone of soil surrounding the roots, and is planted with the trowel in the well-worked soil of the planting area. After planting, weed growth is kept down completely by hand hoeing until the plants are established—usually at the end of the second year.

Such intensive cultivation is, of course, expensive, especially as the policy in most of the forest areas is to give employment to the poor whites rather than use the cheap native labour which would otherwise be available. In spite of the comparatively wide spacing adopted—7 × 7 feet normally for pines—the establishment costs per acre are often of the order of £20. During the last few years there has been a movement to reduce the amount of soil preparation and subsequent cultivation and so cheapen the cost of establishment.

Thinning Practice and Rate of Growth.

The rapid growth of the pine and eucalypt plantations on the better sites proved a constant source of amazement to the visiting delegates. *Pinus patula*, for example, in the Northern Transvaal, averaged in one stand 40 feet in height at 8 years of age, while a stand of *Eucalyptus grandis* at Rooikoppies in the same district reached the remarkable height of 61 feet in only 3½ years. Even at Weza Forest in the south of Natal, which the South African foresters consider a

relatively poor site as far as soil quality is concerned, a stand of *Pinus patula* averaged 21 feet in height at 5½ years of age, while in the next 12 months the height increased to 31 feet.

Such rapid growth naturally complicates the thinning problem very considerably. When a delay of 2 years means an increase in height, not of 5 to 6 feet as in the case of our fastest growing conifers in Britain, but of 10 to 15 feet or more, it is understandable that the critical point should often be missed and the plantations become drawn up and whippy. To get the best results in these very fast-growing stands of such species as *Pinus patula* and *P. insignis* it would probably be necessary to thin them every year from about the 5th to the 15th year; in practice this cannot be done when there are large areas of plantations to be dealt with. In the past thinning has as a rule been delayed too long, it has generally not started until the 9th or 10th year and then been repeated at intervals of 3 to 5 years. The tendency now is to start earlier and thin at not more than 3-year intervals. In South Africa thinnings are always based on number of stems and not on stem classes, and the first thinning is usually made fairly heavy, removing from 40 to 50 per cent. of the stems. One reason for this method of thinning is probably the fact that as a rule there is little differentiation in height in the early life of the stand. Owing partly to the favourable climatic conditions and partly to the soil preparation and subsequent cultivation, the trees get away right from the start. Nowhere has the writer seen young plantations so uniform in height as most of those visited in the Union, but even so it seems questionable if the somewhat mechanical method of thinning on a basis of number of stems per acre can be wholly satisfactory.

The Research Branch of the South African forestry service has established a considerable number of sample plots in different parts of the country, and the particulars on p. 151 indicate the development of certain of these stands. Most of these stands received some thinning prior to the establishment of the sample plots.

The sample plots referred to in the table represent somewhat heavier thinning, especially in the later stages, than has been the general practice hitherto.

Prior to 1931 a considerable amount of pruning was carried out in the State plantations, but in that year it was stopped to await an investigation of its economic aspect. It is now generally agreed that the pruning at an early age of 140 to 200 selected stems per acre should be an economic operation, and the work is likely to be resumed very shortly. In pruning, hand-saws are preferred to pole-saws, and knife-edged tools are not considered practicable in the hands of ordinary labourers. Occlusion is remarkably rapid in the case of fast-growing species such as *Pinus patula*, and a single year's growth may be sufficient to close a branch wound not exceeding one inch in diameter. Where the pruning is carefully done and growth is good it appears that clean timber should be laid on after a maximum of 3 years from the date of pruning.

	Species.	Age.	No. stems per acre.	Av. Ht. ft.	Av. Diam. in.	Volume per ac. u. b. cu. ft.	Current mean annual increment cu. ft.
Port Durnford, Natal.	*Pinus taeda*	12	920	34	5·4	2,290	..
	" "	17	444	47	7·6	2,620	340
	Pinus caribaea	12	660	42	6·0	2,170	..
	" "	15	410	..	..	..	..
	" "	16	250	56	8·1	1,950	340
Empangeni, Natal.	*Eucalyptus grandis*	21	132	116	14·0	6,520	..
	" "	23	103	117	15·3	6,020	440
	" "	27	75	121	17·1	5,490	150
Rooikoppies, Northern Transvaal.	*Eucalyptus grandis*	6	204	81	8·7	2,480	..
	" "	7	168	82	9·7	2,590	415
	" "	9	152	89	10·9	3,180	425
	" "	13	96	96	12·4	2,950	260
Woodbush, Eastern Transvaal.	*Pinus patula*	11	660	58	7·2	4,380	..
	" "	13	470	60	7·8	3,910	480
	" "	17	310	75	9·8	5,020	750
	" "	20	158	90	12·5	4,710	860
	" "	22	158	90	13·1	5,070	180
Cecilia, Cape Province.	*Pinus insignis*	8	625	36	4·8	1,480	..
	" "	12	550	58	6·6	2,740	400
	" "	16	270	78	9·0	3,730	690
	" "	18	270	82	9·4	4,430	390
	Pinus pinaster	23	395	55	7·1	2,460	..
	" "	27	375	58	8·5	3,084	200
	" "	31	242	68	10·3	3,400	335
	" "	33	186	73	11·2	3,330	285

Treatment of Indigenous Forests.

Here and there in the high-rainfall areas of the mountains patches of indigenous forests occur which form a remnant of the once extensive tracts of natural forests which must have clothed many of the hill-sides in the east and south of the Union. For the most part these forests are composed of hardwoods of such species as *Ocotea bullata* (Stinkwood), *Ptaeroxylon obliquum* (Sneezewood), *Olea laurifolia* (Ironwood), *Gonioma Kamassi*, *Curtisia faginea* (Assegai), &c., but as a rule two or three species of the coniferous genus *Podocarpus* also occur. The best of the natural forests remaining are to be found in the constant rainfall zone near Knysna in Cape Province, and the delegates to the Conference were much impressed with the beauty of some of the forests visited. The giant podocarp *P. latifolius* grows to a great size, towering over the hardwoods which compose the greater part of the crop, and attaining diameters of over 7 feet at breast height. The podocarp timber is in demand

for railway sleepers, while stinkwood and other of the hardwoods find a ready sale for furniture, panelling, &c. The forests vary greatly in quality; over large areas practically all the valuable species have been utilized during the past century and little but scrub remains. The treatment of such scrub forests raises a number of problems, but the policy of the Department is to retain the natural species as far as possible, and some very promising research work is in progress with the object of developing methods for regenerating these forests. The better-stocked areas often show quite good regeneration of the podocarps and other major species; the problem here is chiefly one of tending, adjusting the density of the canopy to suit the developing seedlings. Where afforestation areas adjoin blocks of indigenous forest it is not uncommon for the native species to invade the plantations, and in places a fairly dense undergrowth has formed.

The following resolution dealing with silviculture was passed by the Conference. 'The Conference approves the Report of its Committee on Silviculture. It urges upon all Governments the necessity and importance of silvicultural research, without which substantial progress in forestry is impossible. Problems of initial espacements, thinnings, and pruning, particularly in the case of fast growing trees, demand immediate attention.'

OTHER RESOLUTIONS.

The more important of the remaining resolutions passed by the Conference in South Africa are as follows.

(a) *Forest Policy.*

This Conference reaffirms Resolution No. 1 of the First British Empire Forestry Conference (Great Britain, 1920), which sets out the fundamental principles of sound forest policy. It reads as follows:

'In view of the great importance to the Empire as a whole, as well as to each of its component parts, of producing a sustained yield of all classes of timber, of encouraging the most economical utilization of timber and other forest products, and of maintaining and improving climatic conditions in the interests of agriculture and water-supply, each of the Governments of the Empire should lay down a definite forest policy to be administered by a properly constituted and adequate forest service.

'*Survey of Resources.* The foundation of a stable forest policy for the Empire and for its component parts must be the collection, co-ordination, and dissemination of facts as to the existing state of the forests and the current and prospective demands on them.

'*Constitution and Status.* In order to attain continuity in the development of forest resources it is desirable that certain elements of stability be secured in the constitution of the forest policy. This may be done by the following measures:

(1) The definition (where this has not been done already) of forest policy in a Forestry Act or Ordinance.

(2) The reservation for the purpose of economic management and development of forest land under conditions which prevent the alienation of any which is primarily suitable for forest except for reasons consistent with the maintenance of the forest policy as a whole.

(3) The assurance to the forest authority of funds sufficient to carry out the accepted policy for a series of years.

(4) The grant to members of the forestry services of the status of civil servants with due provision for pension.

(5) The appointment as the chief officers of the forestry service of persons having a high standard of training in forestry, their selection and promotion being by merit alone.

(6) The establishment in each of the larger parts of the Empire and for the Colonies not possessing responsible government collectively, of an officer or officers, having special duties of advising as to forest policy and surveying its execution.'

This Conference draws the attention of all Governments of the Empire to the fact that the above statement has been critically examined by successive Empire Forestry Conferences and has emerged unchanged. On the other hand, under the stress of the world economic depression there have been departures from some of these principles during the last few years.

This Conference, having in view the improvement of economic conditions within the Empire, urges that all Governments of the Empire should review their forest policies in the light of the Resolutions of 1920.

(b) *Preservation of Types of Indigenous Forest.*

The Conference desires to bring to the notice of Governments in the British Empire the desirability of setting aside suitable areas of indigenous forest to be preserved in their primeval form.

(c) *Botanical Nomenclature.*

(i) *Scientific Names.* The Conference is strongly impressed by the evidences of confusion arising in administration and in forest work by changes in the scientific names of trees of economic importance. The Conference therefore supports the representations which have been made by the Imperial Forestry Institute to the Sixth International Botanical Conference, Amsterdam, 1935.

(ii) *Botanical Orthography.* The Conference recommends that the Forest Departments of the British Empire adopt the system of decapitalizing specific names.

(d) *Tropical Forestry in Relation to Agriculture.*

The Conference draws the attention of Governments to the close relationship that should be maintained between forestry and agriculture in dealing with many problems of tropical husbandry.

In regard to African conditions the increasing importance of forestry in assisting in the control of trypanosomiasis is emphasized.

On the invitation of the Government of India the next Conference will be held in India in 1940.

MYCORRHIZAL ASSOCIATIONS IN SCOTS PINE

A NOTE BY M. C. RAYNER

IN a paper published recently in this journal (1) certain abnormal mycorrhizal associations included provisionally under the general title of 'pseudomycorrhiza' were figured. One of these, involving a secondary association of dark brown mycelium with hymenomycete mycorrhizas, was believed to be due to the fungus *Mycelium radicis atrovirens* described originally by Melin from Sweden, a strain of which, identical in pure culture with that from Sweden, is widely distributed in the area (Pl. XII, figs. 1, 2, 5).

Subsequent to publication, my attention was drawn to a paper by Hatch (2) describing a 'jet-black mycelium forming ectotrophic mycorrhizae'. There is considerable difficulty in distinguishing the various types of dark-coloured sterile mycelium found in association with tree roots and corresponding confusion in the records. The fungus described and provisionally named *Mycelium radicis nigrostrigosum* by Hatch is believed to be identical with that forming the 'D Mycorrhiza' recorded by Melin from Swedish soils (3). The mycelium often occurs on the same root with that of *M. r. atrovirens*, with which it may easily be confused. In mycorrhizal association it shows a palisade-like arrangement of hyphae in the mantle believed to be characteristic.

Hatch has had both *M. r. atrovirens* and *M. r. nigrostrigosum* under observation in pure culture with *Pinus Strobus* L. and *P. resinosa* Ait. alone, and also associated with certain mycorrhiza-formers. The mycelia grow at different rates, and colonies of the two fungi are readily recognizable on some substrata. Hatch's experiments also afford criteria for distinguishing them in association with *P. Strobus* and *P. resinosa* in pure culture. Under these conditions *M. r. atrovirens* was invariably pathogenic to the host, while *M. r. nigrostrigosum* formed mycorrhizas directly, or developed secondary mantles over those of other mycorrhiza-formers.

The purpose of the present note is to correct the designation of the dark-coloured hyphae shown in the photomicrographs referred to above. This mycelium, attributed to *M. r. atrovirens*, is now believed to be that of the fungus recently named *M. r. nigrostrigosum* by Hatch.

In the Dorset area, from which this material was collected, hyphae of both these fungi are common as secondary growths on the mantles of mycorrhizas of Scots pine. Those figured, now believed to show secondary infection by *M. r. nigrostrigosum*, were collected from trees showing degeneration of growth.

This fungus has also been observed as a mycorrhiza-former on Scots pine on moorland in the north of England. Here, also, the material was collected from a degenerating plantation. It will be of interest to ascertain whether it is widespread in Great Britain as a 'typical mycorrhizal organism' as recorded by Hatch in the paper cited above.

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(2) Hatch, A. B. (1934): 'A Jet-black Mycelium forming Ectotrophic Mycorrhizae.' *Svensk Botanisk Tidskrift.* xxviii, 1934, pp. 369–83.

(3) Melin, E. (1927): 'Studier över barrträdsplantans utveckling i råhumus. II. Mykorrhizans utbildning hos tallplantan i olika råhumusformer.' *Meddel. fr. Statens Skogsförsöksanst.*, xxiii, 1927, pp. 433–94.

SOCIETY'S AND OTHER NEWS

EIGHTH ANNUAL EXCURSION

The excursion was held in London in conjunction with the Annual General Meeting on Friday, 31 May. Those who attended had a unique opportunity of studying the production of veneers and plywood by some of the leading firms in Great Britain. In the morning members assembled at the showrooms of Messrs. William Mallinson & Sons, Ltd., Hackney Road, where examples of many of the finest veneers, in the form of large panels, are displayed to advantage. The party then proceeded to the works of Messrs. John Wright & Sons (Veneers), Ltd. The bulk of the plywood used in Great Britain is imported from abroad; for economic reasons only the highest qualities can be manufactured in this country. The selection of timber and all the stages of its manufacture into plywood and veneers are therefore attended with a considerable amount of skill. In a short tour of Messrs. Wright's yards members were able to see for themselves the type of timber required for this purpose. Of special interest to English foresters was the large stock of fine oak butts, frequently exceeding 5 feet in diameter, and destined for conversion into quartered veneers. No less striking were the stocks of almost cylindrical Canadian birch logs, specially selected for rotary cutting. Inside the factory, peeling and slicing machines of various types were seen at work and the process of drying the veneers was demonstrated. Although the decorative value of the most highly prized veneers is often due to distortion of the grain in rootstock, crotch, or burr, some very fine panels are obtained from the normal figure of well-grown wood such as quartered oak. In other cases some freak of nature may result in all the wood of a normally straight-grained tree being contorted, although to outward appearance there is nothing remarkable about the log. Sycamore, which sometimes yields whole logs of beautifully figured wood, is a case in point.

The actual manufacture of plywood was seen later in the day at the works of the Aeronautical Panel and Plywood Company, which specializes in high-class plywood and veneering. Both processes demand the use of elaborate machinery for the gluing, pressing, and drying operations, &c., together with a high standard of craftsmanship, especially in the work of veneering. There is food for thought in the fact that the plywood industry has largely overcome the natural disadvantages inherent in timber as a raw material. Plywood products will undoubtedly play a more and more important part in the utilization of timber, and the special requirements of the industry deserve the attention of the forestry profession.

The Society is indebted to the principals of the firms who kindly provided facilities for this excursion, and to their representatives who acted as guides.

SIXTH INTERNATIONAL BOTANICAL CONGRESS

Stability of Tree Names

At the Sixth International Botanical Congress, held at Amsterdam, from 1 to 7 September 1935, two proposals embodying the principle of the conservation of specific names (*nomina specifica conservanda*) were offered: one by Mr. J. Adams, Botanist, Central Experimental Farm, Ottawa, Canada; the other by Professor R. S. Troup, on behalf of thirty-eight Forestry Departments and other institutions and individuals interested in the conservation of long-used names of trees and other plants of economic interest.

Before the Congress met in open session, the Permanent Bureau of Nomenclature had considered the various proposals on nomenclature sent in to the Congress, and had rejected these two, among many others, the first by 7 against and 4 in favour, and the second by 6 against and 2[1] in favour.

Dr. Sprague and other members of the Permanent Bureau recommended, however, that the principle involved should be discussed, inasmuch as it was one that 'intimately concerned workers in applied botany'. This was agreed to, but after discussion the Congress rejected the principle by 208 votes against and 61 in favour.

Mr. Ramsbottom, Keeper of Botany, British Museum (Natural History), South Kensington, then suggested that a reasonable compromise would be to draw up a list of names of economic plants, as sanctioned by an International Committee, i.e. drawn up according to the International Rules. Separate lists could be printed in the Appendix to the Rules if asked for by the interested section of botanists. Fixity of specific epithet, he pointed out, not specific name, is what is really wanted; to fix specific names (the generic name and specific epithet) would not be in the interests of taxonomy. Dr. Rendle suggested the addition of a proviso that 'this list may remain in use for a period of ten years'. These suggestions were then proposed as a motion, which was accepted by the Congress.

The following special Committee for the Nomenclature of Economic Plants was appointed to deal with the list:

Burtt Davy, J., Imperial Forestry Institute, Oxford, to supply a list of trees.
Chittenden, F. J., Royal Horticultural Society, London, to supply a list of horticultural plants.
Exell, A. W., British Museum (Natural History), South Kensington, London.
Eyma, P. J., University of Utrecht.
Harms, H., Botanisches Museum, Berlin-Dahlem.
Hochreutiner, B. P. G., Professeur au Collège Supérieur, rue St. Victor 10, Geneva.
Rehder, A., Arnold Arboretum, Jamaica Plain, Massachusetts, U.S.A.
Robyns, W., Jardin Botanique de l'État, Brussels.

Miss M. L. Green, The Herbarium, Royal Botanic Gardens, Kew, was appointed honorary secretary of this committee.

While it is to be regretted that the Congress did not see its way to accept the principle of the conservation of specific names which are well established in use, even though they may not be the oldest under the International Rules, the compromise effected is a step in the right direction. It places the responsibility for the interpretation of the

[1] It is understood that three members refrained from voting on the latter motion.

rules as it affects the names of forest trees upon an international committee. This opinion will have the weight of authority behind it. Being international the committee will be able to co-ordinate the names of forest trees grown both in Britain and on the Continent; the name *Ulmus campestris*, as at present used on the Continent, does not refer to the same tree known by that name in Britain; it will be for this committee to decide as to which tree, if any of them, should be so called.

A list which is stabilized for ten years will probably remain in permanent use; it will have cleared the ground of a lot of doubtful synonyms which have caused much of the uncertainty as to the validity of names.

Although the list to be prepared and published is to be 'according to the International Rules', this does not mean that names which have recently been resurrected to replace well established ones are necessarily valid under the rules. Each case will have to be considered on its merits; for example, it has recently been proposed that the well-known name *Eucalyptus acmenioides* Schauer (1843) should be replaced by the little-known name *Eucalyptus triantha* Link (1822). This species is widely cultivated (e.g. in India, Ceylon, tropical Africa, South Africa, the Mediterranean region, and California) under the name *E. acmenioides*. In 1907 Maiden (*Crit. Rev.*, Pt. 2, p. 263) gives *E. triantha* Link as a probable synonym of *E. acmenioides*, adding 'not absolutely settled, in my mind, but very probable'. In subsequent issues (Pt. 65, Pl. 265 (1925); Pt. 70, Pl. 287 (1928)) Maiden used the name *acmenioides*, ignoring *E. triantha* Link. It is evident, therefore, that Maiden in his more mature years abandoned the idea suggested in 1907 that *E. acmenioides* was synonymous with *E. triantha* Link.

In the absence of evidence that Maiden was in error in continuing to use the name *E. acmenioides* it seems best to treat *E. triantha* as a *nomen ambiguum*.

As it is important that the committee should get to work as soon as possible, Dr. Burtt Davy will be glad to receive lists of tree names which are in doubt, or about the validity of which there may be question.

THE NATIONAL HOME-GROWN TIMBER COUNCIL

In March last, the Chairman of the Forestry Commission announced a scheme for the establishment of a National Home-grown Timber Council which would be concerned with propaganda, economics, statistics, trade information, and limited research into problems connected with home-grown timber. The Council would consist of representatives of timber growers, timber merchants, and others, and be presided over by an independent chairman nominated by the Forestry Commission. The membership of the Council has now been announced as follows:

Chairman: Sir Edward Grigg.

Lord Clinton and Mr. W. E. Hiley representing English Timber Growers;

Col. The Hon. I. M. Campbell and Capt. G. I. Campbell representing Scottish Timber Growers;

Mr. H. E. Newsum and Mr. J. W. C. Agate representing English Timber Merchants;

Mr. J. T. Smith and Mr. T. McAinsh representing Scottish Timber Merchants;

Sir Alexander Rodger representing the Forestry Commission;

and

Mr. W. A. Robertson representing the Forest Products Research Laboratory.

The Secretary and Chief Executive Officer is Dr. S. E. Wilson, and the address of the Council, 11 Victoria Street, S.W.1.

REVIEWS

Grundlegung einer forstlichen Betriebslehre. Dr. Christof Wagner. Julius Springer, Berlin, 1935. 337 pp. Unillustrated. RM. 21.50.

Review by R. Bourne

THE author contends that although the theories of forestry are well understood, their application in practice is frequently at fault, and that there is in consequence ample scope for a new work on the subject. It must be understood that he is almost a fanatical protagonist of the need for a system of concentrated fellings in order to ensure a proper ordering of the management. As the originator of the *Blendersaumschlag*, which bears his name, he may be forgiven a considerable bias in that direction, more especially as he abhors large felling areas, but his issue of a challenge to German foresters to maintain that for which their predecessors had fought and established through one and a half centuries—a solid front against *dem wilden Blenderbetrieb*, or the Savage Selection system—is bordering on the melodramatic. To any student of the selection system, both in theory and practice, Wagner has exposed his ignorance of the one and his limited experience of the other. On this subject his appeal for clear thinking is lost as soon as it is made, the cause being his own confusion of thought. For example, in ridiculing Flury's statistical comparisons of the amount of clean timber produced in adjoining selection and regular forests, he confuses length of bole free from branches with volume of timber free from knots, thus perpetuating the common error involved in the assumption that a long stem free from branches necessarily contains a high volume free from knots. Again, all his instances of poor timber being produced under selection are drawn from forests which have only been under conversion from regular to selection working for 30–40 years, another common error of biased critics of irregular silviculture. When, however, he turns to the consideration of regular systems of fellings his presentation of the facts and his arguments are less open to criticism. Nevertheless, he goes so far as to claim that his *Blendersaumschlag* is the system *par excellence* under a wide variety of conditions from the pine of the sand plains to the spruce at high elevations. His many dissertations on the practice of this system fill more than half the book, the chapters dealing with the actual technique of thinnings and regeneration fellings being of great interest. They are, however, of more interest to the forester in practice than to students at forest schools, for whom the book is too advanced.

'Ett Försök till Klassifikation av Skogsmarken i Sverige.' By Olaf Tamm. *Medd. från Statens Skogsförsöksanstalt*, 1934, Häfte 28, pp. 269–98.

Review by Alex Muir

IN this short paper Tamm gives a brief account of the relationships between soils and vegetation in Sweden. Beginning with a consideration of the various factors which affect both soil and vegetation, e.g. climate, topography, geological formation, ground water, &c., he passes on to an excellent summary of the main vegetation types with a short description of the soil characteristics of each. In the past, Tamm has published detailed reports on the development of Swedish forest soils and their dependence on the ground vegetation and groundwater. In these he has shown that it was necessary to divide Sweden into two regions, middle and south, and north, for the purposes of soil and vegetation studies. In the northern region, tree growth is dependent to a greater

extent on the soil parent material than it is in the south, and the soil and humus types are to some extent different for these two regions. The soils developed in both areas include brown earths, iron and humus podzols, and gley soils, with innumerable transition types. The main humus types recognized are mull, raw humus, and peat.

The most interesting point which has emerged from this work is the dependence of the rate and degree of podzolization on the composition of the ground vegetation. This confirmed Cajander's theory that the ground vegetation was the most important factor in the estimation of the silvicultural value of forest land. This point is extremely well brought out in the present paper, free as it is of the great detail which is found in Tamm's larger works. The vegetation types are listed for both north and south Sweden, and the humus and soil types, with some general notes, are given for each. The following is a rough translation of an example described for south Sweden.

'The field layer is dominated by *Calluna vulgaris* and *Vaccinium Vitis-Idaea*; the bottom layer by pure lichen: Heath type. Raw humus 1–2 cm. or at the most 4–5 cm. Ordinary podzol.'

'This is the poorest type of ground. The bad state of the soil, however, may occasionally be due to unsuitable treatment. Whether this is the case or not can be elucidated by comparative investigation in areas on the same geological formation. The basic mineral index may be found of use in this connexion.'

The following table, abstracted from the notes on the north Swedish types, gives a clear idea of the dependence of soil development on different types of vegetation.

Vegetation type.	*Humus layer.* cm.	*Leached layer.* cm.
1. Short *Calluna*, *Vaccinium Vitis-Idaea*, lichens . .	1–2	2–3
2. *Calluna*, *V. Vitis-Idaea*, some *V. Myrtillus* mosses including *Hylocomium parietinum*	1–4	3–7
3. *V. Vitis-Idaea*, *V. Myrtillus*, mosses	1–5	7–12
4. *Calluna* and *V. Vitis-Idaea* with frequent *Ledum palustre* and *V. Myrtillus*; mosses and *Sphagnum acutifolium* .	3–10	10–12
5. *V. Myrtillus* dominant, some *V. Vitis Idaea*; mosses. *Vaccinium* type without peat	4–10	7–12
6. *Vaccinium Myrtillus* dominant; mosses. *Vaccinium* type with peat	5–20	10–12

Owing to human influence in this country it may never be possible to formulate such general statements about the relationship between soil and vegetation, but careful study may make it possible to bring about a closer connexion between forest ecology and soil investigations.

'The Starch and Related Polysaccharides of Certain Hardwoods. 1. The Preparation and Properties of Oak and Walnut Starch.' By W. G. Campbell. *Biochem. Journ.* xxix. 1935, pp. 1068–1080.

Review by K. F. Bamford

THIS paper is the first of a series of publications on a subject of interest not only to wood chemists but to plant chemists in general. As an introductory paper on this subject the work is confined to a description of the general properties of wood starch, the method of isolating it in a pure state, and a preliminary investigation of its composition.

The starch present in the parenchymatous cells of English oak (*Quercus* sp.) is shown to resemble the known starches in certain properties only. It occurs in the form of minute particles of a gel, which can readily be dispersed with hot water. This phenomenon is illustrated by an interesting series of photomicrographs and is utilized in developing a quantitative method for isolating the starch. By repeatedly extracting 50–60 mesh sawdust of not more than 12 per cent. moisture content with water at 100° C., it is possible to remove all minute traces of starch from the wood. Some difficulty was at first experienced in avoiding contamination of the starch by tannins and colouring-matter, but this was eventually overcome by introducing a preliminary extraction with water at 60° C. By this means it is possible to extract practically all the colouring-matter and tannins, leaving the starch grains intact. The starch is then removed from the wood by repeated extractions at 100° C. The extracts are concentrated, and addition of acetic acid and alcohol precipitates the starch, which is finally purified by extraction with various solvents. Full details of the experimental technique are given, and the yields of wood starch from the sapwood of winter-felled English oak and walnut (*Juglans regia*) are recorded. It is claimed that the wood starch isolated in this manner is a suitable source of nourishment for the larvae of *Lyctus* powder-post beetles.

The usual method of estimating starch by fermentation with takadiastase is applied to both potato starch and the isolated wood starch, and comparison of the results reveals a significant chemical difference between the two. The application of this method in the estimation of wood starch is critically discussed.

The physical and chemical properties of the isolated product are investigated, and values are given for elementary analyses, optical rotation, and furfuraldehyde yield. Its composition is further studied by examination of the products of hydrolysis with 2 per cent. sulphuric acid, and investigation of the course of hydrolysis over a period of 16 hours. These latter results are illustrated graphically. On the basis of the experimental work, it is concluded that wood starch is an acid polysaccharide of which 90 per cent. is composed of anhydroglucose residues. It is suggested that the remainder consists of an aldobionic acid which may be partly methylated. Evidence is given that, after the complete extraction of the wood starch, the cell walls of oak sapwood still contain a polysaccharide which is chemically allied to the starch of the cell contents. Examination of this substance is in progress.

The author concludes with a suggestion that wood starch constitutes the missing link between the products of the chloroplasts of the leaf and the hemicelluloses of the cell wall. It is in this respect that the great value of the paper lies. The author is undoubtedly to be congratulated on being the first to isolate starch from wood, but if this work and that which is still in progress leads to the elucidation of the intricate chemical processes taking place during the formation of woody tissue, the value of the paper will be beyond dispute.

'Diagnoses d'espèces et variétés nouvelles de *Pseudotsuga* américains.' By Mlle F. Flous. *Travaux du laboratoire forestier de Toulouse*, tome i, vol. ii, article vi, 1934, pp. 1–18; 7 plates.

Review by M. Y. Orr

THERE are three well-known species of *Pseudotsuga* indigenous to western North America: *P. Douglasii* Carr (*P. taxifolia* Britt.), a native of the Pacific Coast region —represented in the northern Rocky Mountains by the variety *caesia*, *P. glauca* Mayr which is confined to the central and southern Rocky Mountains, and *P. macrocarpa*

Mayr, which occupies an isolated area in the mountains of southern California. In the paper under review, Mlle Flous, who has already described two new species of *Pseudotsuga* in a previous article, now increases the number of American forms by the addition of six other species and two varieties, some of which carry the range of the genus beyond the confines of the United States.

The species recorded here for the first time are *P. vancouverensis* (Vancouver Island), *P. californica* (southern California), *P. Merrilli* (Rocky Mountains), *P. Rehderi*, *P. globulosa* and *P. Flahaulti* (southern Rocky Mountains and Mexico), while the two species described elsewhere are *P. macrolepis* and *P. Guinieri*, both of which are essentially Mexican in their distribution. The so-called varieties are merely forms of *P. Guinieri* which differ in the size of the cone, and these have been named *parvistrobus* and *mediostrobus*. Unfortunately Mlle Flous has complicated matters somewhat by taking the type of the species referred to as the type of the variety *parvistrobus*, with the result that the species now becomes the variety, and the greater equals the lesser, which is absurd! This paradoxical situation could have been avoided simply by the use of one varietal name, i.e. *mediostrobus*. It may be pointed out in passing that a slight orthographic error is apparent in the specific names *Merrilli* and *Flahaulti*, in both of which the final letter should have been repeated in accordance with the Rules of Nomenclature.

The descriptions of the new species are accompanied by excellent drawings of the cones and portions of the vegetative organs, together with diagrammatic representations of the more salient features of the anatomy of stem and leaf. The article concludes with a key for the identification of the species mentioned in the text, although the usefulness of this is diminished to some extent by a regrettable lack of balance in its construction. A map to illustrate the distribution of all the species of *Pseudotsuga* found in North America accompanies the key.

Whether, or not, all the forms of *Pseudotsuga* to which specific names have been given here can lay claim to specific rank on that account is a matter upon which it is impossible to pronounce an opinion without first having seen the type specimens, and these are not readily available. It is not disputed that over such a wide area, and under such diverse climatic conditions, a multiplicity of forms may have arisen, but, judging by the illustrations of those that are described in this paper, it would seem that not all of them are sufficiently distinct to justify the creation of new species *en bloc*.

Thinning and Pruning.

(1) *Studies in Tolerance of New England Forest Trees.* By W. R. Adams. University of Vermont and State Agricultural College, Bulletin 390, 1935.

(2) *Artificial Pruning in Coniferous Plantations.* By R. C. Hawley and R. T. Clapp. Yale University, School of Forestry, Bulletin No. 39, 1935. Price 50 cents.

Review by the Editor

THERE has been a considerable advance in recent years in knowledge of the effects of different thinning practices on crops, and this is indicated by the revision necessary in the section on thinning in the second edition of Dengler's *Waldbau* noticed in this number. There is a great deal more to learn, however, indeed practically everything, on the effect of thinning on the physical factors of the site which is the subject of Adam's bulletin (1). The studies were made on *Pinus strobus* and *P. silvestris* at Burlington, Vermont, U.S.A. The ages of the plantations were 20 and 18 years respec-

tively, and they were small in area—about an acre. In each, a plot was thinned and one not thinned. The areas of the plots varied from 0·05 to 0·15 acres. There was no replication of plots. The thinnings were made in 1929 and 45 per cent. of the basal area was removed in *P. strobus*, the original spacing being 6 feet by 4 feet, and 30 per cent. in *P. silvestris*, the original spacing being 5 feet by 5 feet; the latter was a B grade and the former probably between B and C.

The physical factors were measured by two stations on each plot, one in the crown by means of a tower, and one at ground level. The usual measurements were made: air temperature, relative humidity, wind movement, evaporation, solar radiation, and at the ground level precipitation. Soil temperature and moisture content at various depths were also recorded. The observations extended from 1930 to 1932.

It would appear to be a valid criticism that the plantations were so small that the physical factors might not be typical of forest conditions. Further, no observations were made to determine what were the variations within the stand, and in the absence of replications, it cannot be determined whether the differences noted in the thinned and unthinned plots were the result of the difference in treatment and not due to site variation. It is appreciated, however, that adequate replication would have involved a heavy increase in labour and cost.

The results, if suggestive rather than conclusive, are interesting. In White pine, the thinning increased: solar radiant energy, wind movement, evaporation in the crowns and at ground level; the amount of precipitation reaching the soil; the available moisture to a depth of 3 feet during the periods when the soil moisture content was low; and the soil temperature at 6 and 18 inches depth. The larger trees showed an increase in diameter and volume growth which still continued at the end of four years. There was no effect on the specific gravity of the timber.

The effects produced by the lighter thinning on the Scots pine were similar, but less marked. Its effect was diminishing in the fourth year after thinning.

This study is to be welcomed, and it is hoped that it will be extended with adequate replication.

Hawley and Clapp's bulletin (2) is an informative study of pruning in coniferous plantations, and all who have the management of such should read it. The practice at Eli Whitney Forest at New Haven, Connecticut is described. The following are some of the principal points:

1. The species are principally *Pinus strobus*, *P. resinosa*, and *Picea abies*. The stands are partly pure and partly a mixture of the two pines. The average spacing is 6 feet by 6 feet.

2. Early pruning is advocated, and both dead and the lower living branches are removed.

3. Generally, pruning is done up to 17 feet, and the work done in several operations. Successive pruning is practised so that the knotty core is kept to not more than 6 inches in diameter.

4. Normally 150 to 200 per acre of the best trees are selected for pruning. Subsequent thinning is directed to favour these trees.

5. Pruning is normally done in the winter, because it fits in with other work.

6. Curved pole-saws and curved hand-saws used with light ladders are both used for high pruning. Both methods are similar in rate of work, while hand-saws give better work. The curved pole-saws are light bladed, 14 inches long, tapering from 4 inches to 2 inches, 8 points to the inch.

7. The following number of lineal feet can be pruned per hour in White pine:

0 to 7 feet	95·2 feet	hand-saw
7 to 17 „	76·6 „	2 operations ladder method
7 to 17 „	74·9 „	Pole-saw.

8. The cost of pruning up to 17 feet on the basis of labour at 50 cents per hour, i.e. almost three times that in this country, is about sixpence per tree for White pine. This is about £5 per acre on the basis of 200 trees pruned, and is similar to experience in this country, allowing for the difference in labour cost.

9. The physical effects of pruning have been studied to some extent. Pruning of live branches of White pine may result in 'pitch pockets'. Some discoloration may also result. The general effect is to increase somewhat the core of low grade timber, but this is offset many times by the timber produced free from knots.

The Duke Forest. Duke University Forestry Bulletin No. 1. By Clarence F. Korstian and William Maughan, Durham, North Carolina, 1935.

Review by the Editor

DUKE University was founded in 1924, and it has since purchased considerable tracts of land, mainly forest, adjoining and near the University buildings. This tract, now over 4,000 acres in extent, constitutes the Duke Forest. It is intended to manage this forest partly as a demonstration forest, so that owners of forest properties may be able to see forestry in practice, partly as a research centre for the study of problems in the growing of timber and in sciences basic thereto, and partly as a field laboratory in connexion with a proposed graduate school of forestry in the University.

This bulletin describes the forest and its objects. It is typical of its region and consists of Pine types—principally *P. taeda*, *P. echinata*, and *P. virginiana*, Pine-Hardwood types—the southern pines with *Quercus* spp. and *Liquidambar styraciflua*, Upland Hardwood types—*Quercus* spp., and Bottomland types—*Liquidambar*, *Liriodendron tulipifera*, and *Bertula nigra*. There is wide scope, therefore, for the study of varying conditions.

In all countries, the tendency is for the extension of state as opposed to private forestry. Whatever advantages may accrue from this, there is a danger that it may lead to excessive uniformity, which would militate against continued development and technical progress. One corrective would be the existence of such demonstration forests directed by men, not only competent and energetic, but of original and imaginative outlook. The academic connexion should not only facilitate contact with scientific interests, but also secure detachment and freedom from undue restraint. Those who know Professor Korstian personally will agree that he is well fitted to direct such an adventure, and this addition to America's academic forests should be a means to the advancement of forestry and an example to follow.

NOTICES

Fifteenth Annual Report of the Forestry Commissioners. H.M. Stationery Office. Price 2*s.* plus postage.

IT has been the custom of the Forestry Commissioners to review their work in greater detail every five years; the fifteenth report is the most important so far published both in scope and interest, and constitutes an important state document. All who are interested in forestry either professionally or otherwise should obtain and read this report. It is specially recommended to foreign experts who may want to know the present position of forestry in Great Britain.

At 30 September 1934, the Commissioners had under their charge 909,000 acres of land, of which 544,000 acres will ultimately be forest. At that date 316,000 acres were plantations, 66,000 acres being acquired or transferred, i.e. not planted by the Commissioners, and 1,233 forest workers' holdings had also been established.

The Commissioners' views on the forestry needs of this country are stated at some length. As judged by the Acland programme, afforestation by the state and replanting by private owners have fallen into serious arrears. They consider that their programme of planting should be increased from the present figure of about 20,000 acres per annum to 30,000 acres for the next four years, expanding further to 45,000 acres later. They estimate that the latter figure will necessitate a government contribution of £1,000,000 per annum, compared with the present figure of £450,000. It would appear, however, that increased land acquisition is the most immediately pressing need.

Data are given of rate of growth in the Commissioners' plantations, and there is some discussion of improvements in forest technique, such as ploughing of moorlands, contour drainage and turf planting, and the treatment of hardwood scrub areas. The varied and important work done by the Commissioners' research branch is reviewed.

An interesting development has been the establishment of training centres for unemployed men, established by the Ministry of Labour in co-operation with the Commissioners. This is a parallel development to what has taken place in Germany and the United States of America. There are observations on national parks and youth hostels and the contributions made thereto by the Commissioners. Of general interest, is the vigorous defence of the Commissioners' attitude towards amenity and hardwoods.

These are some of the principal points, but all, whether foresters, biologists, or members of the general public, will find something of interest in this publication.

Forest Products Research Records Nos. 1 *to* 4. H.M. Stationery Office. Price 6*d.* each.

A PERENNIAL source of trouble to research institutes is to make their results available to the public for whom they work. The Forest Products Research Laboratory appear to appreciate this difficulty, and they have begun the issue of booklets on various subjects connected with their work. They are written in simple language and are cheap. All who handle timber should obtain and read them as they are issued. It is anticipated that 10 per annum will be published. The titles of the first four are:
No. 1. 'The Testing of Timbers at the Forest Products Research Laboratory.'

This is a general description of the different sections of the Laboratory and the work they carry out.

No. 2. 'Strength Tests of Structural Timber. Part. I. General Principles with Data on Redwood from Gefle and Archangel.'

The lack of such data for European timbers is stressed, and a beginning is made to supply it.

No. 3. 'Experiments on the Preservation of Mine Timber.'

Little preservation of mine timber is done, and data are given to show that considerable economy would result from the use of 2 per cent. sodium fluoride, &c.

No. 4. 'Timber Seasoning'.

This is an interesting pamphlet, but it is doubtful if it is sufficiently detailed to be of real use. The subject is rather large for this method of treatment.

Journal of the British Wood Preserving Association. Vol. V, 1935. Price 7*s.* 6*d.*

AS usual, this volume includes the lectures and the discussions which followed at the meetings held by the Association during the winter. They were: 'The Seasoning of Timber', by Mr. R. A. G. Knight; 'Mining-Timber and its Treatment', by Mr. James Tonge; and 'Some Aspects of Wood Preservation in Australia and U.S.A.', by Mr. S. F. Rust. There are also papers on: 'Preservative Tests and Durability Trials with Native Timbers of the Copper Belt of Northern Rhodesia', by Mr. C. E. Duff; 'Wood Preservation in Malaya', by Mr. A. V. Thomas; 'Cross-Ties used by Canadian Railways', by Mr. J. F. Harkom; and 'A Standard Laboratory Test for Wood Preservatives', by Mr. W. P. K. Findlay.

The Use and Misuse of Land. By R. M. Gorrie. Oxford Forestry Memoirs, No. 19, 1935. Clarendon Press, Oxford. Price 6*s.*

THIS memoir records the observations made by Dr. MacLagan Gorrie during a four months tour in the United States of America as a Leverhulme Research Fellow. While Dr. Gorrie obviously made good use of his time, such a survey inevitably adds little new information, and tends to be scrappy. Nevertheless, the problems, principally of erosion, are lucidly set forth and well illustrated, and the data available from the United States discussed. The subject is of first importance, particularly outside temperate Europe, and all contributions to its study are to be welcomed.

Fifteen South African High Forest Timber Trees. By L. Chalk, M. M. Chattaway, J. Burtt Davy, F. S. Laughton, and M. H. Scott. Clarendon Press, Oxford, 1935. Price 7*s.* 6*d.*

THIS volume follows the same general lines as the two previous volumes on East African and West African trees. It appropriately came out for the meeting of the Empire Forestry Conference in South Africa. In addition to botanical and timber descriptions and silvicultural notes on the fifteen species, there is a general introduction on South African high forests. The illustrations are excellent.

Waldbau. By A. Dengler. Second edition. Julius Springer, Berlin, 1935. Price 30 Gold Marks.

DENGLER'S 'Silviculture' occupies an important place in German forestry literature. The first edition was reviewed in *Forestry* IV (1), p. 56, and the second edition follows the same lines as the first. The opportunity has, of course, been taken

to bring it up to date, and this is perhaps principally true of the section on thinning. Dengler occupies a middle position in German silviculture, hence his book can be recommended as a balanced work which reflects current general opinion. It should retain its place for many years.

Wood Utilization in Finland. By EINO SAARI. Communicationes ex Instituto quaestionum forestalium Finlandiae editae. 14, 1934.

PROFESSOR SAARI occupies an important place amongst forest economists in Europe, and this survey will enhance his reputation. It is a task of great magnitude to arrive at a detailed assessment of wood utilization in any country. The method used was an indirect one, namely ascertaining in the first instance the amount of wood used for different purposes, and deriving from these figures the total amount of wood utilized, and from that the total amount cut. The year 1927 was taken for assessment purposes. The total cut in that year was approximately 43 million cubic metres. It slightly exceeded the estimated annual growth over the country as a whole, there being a considerable deficit in southern Finland, and a surplus in northern Finland. Any survey elsewhere will have to take into account the methods worked out by Saari and his colleagues.

A Swedish-English Vocabulary for Foresters. By J. L. DEEN, A. B. BENSON, and M. S. DANNFELT. Bulletin No. 40. Yale University, School of Forestry, 1935. Price 1 dollar.

THIS publication will be very useful to those who, without a knowledge of Swedish, wish to translate forestry papers, and find difficulties because forest terms are not included in ordinary Swedish dictionaries.

La Milizia forestale. Anno XII.

THIS is the annual report for 1934 of the Italian Forest Militia. It can be stated with confidence that no forest report has ever been published to rival this one in *de luxe* production. It is printed on art paper and is illustrated not only with numerous photographs but with many coloured plates reproducing pictures in the modern style. The first plate in colour depicts Il Duce in a somewhat futuristic way sowing tree seed in a forest nursery. We feel certain that the annual reports of the Forestry Commissioners would enjoy a much wider sale if, say, Mr. Stanley Baldwin was depicted in a similar posture. The illustrations suggest a greater emphasis on the *milizia* than on the *forestale*, but nevertheless, during the year over 30,000 acres were afforested besides the carrying out of extensive roadwork and protection activities in the mountains. Even in Cirenaica and Tripolitania over 600 acres were planted. In forestry as in other departments the Italians are undoubtedly showing energy.